



# **NetApp Hybrid Multicloud with Red Hat OpenShift**

NetApp Solutions

NetApp  
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# NetApp Hybrid Multicloud with Red Hat OpenShift Container workloads

## NetApp Hybrid Multicloud solutions for Red Hat OpenShift Container workloads

NetApp is seeing a significant increase in customers modernizing their legacy enterprise applications and building new applications using containers and orchestration platforms built around Kubernetes. Red Hat OpenShift Container Platform is one example that we see adopted by many of our customers.

### Overview

As more and more customers begin adopting containers within their enterprises, NetApp is perfectly positioned to help serve the persistent storage needs of their stateful applications and classic data management needs such as data protection, data security, and data migration. However, these needs are met using different strategies, tools, and methods.

**NetApp ONTAP** based storage options listed below, deliver security, data protection, reliability, and flexibility for containers and Kubernetes deployments.

- Self-managed storage in on-premises:
  - NetApp Fabric Attached Storage (FAS), NetApp All Flash FAS Arrays (AFF), NetApp All SAN Array (ASA) and ONTAP Select
- Provider-managed storage in on-premises:
  - NetApp Keystone provides Storage as a Service (STaaS)
- Self-managed storage in the cloud:
  - NetApp Cloud Volumes ONTAP(CVO) provide self managed storage in the hyperscalers
- Provider-managed storage in the cloud:
  - Cloud Volumes Service for Google Cloud (CVS), Azure NetApp Files (ANF), Amazon FSx for NetApp ONTAP offer fully managed storage in the hyperscalers

## ONTAP feature highlights



<p><b>Storage Administration</b></p> <ul style="list-style-type: none"> <li>Multi-tenancy</li> <li>FlexVol &amp; FlexGroup</li> <li>LUN</li> <li>Quotas</li> <li>ONTAP CLI &amp; API</li> <li>System Manager &amp; BlueXP</li> </ul>	<p><b>Performance &amp; Scalability</b></p> <ul style="list-style-type: none"> <li>FlexCache</li> <li>FlexClone</li> <li>nconnect, session trunking, multipathing</li> <li>Scale-out clusters</li> </ul>
<p><b>Availability &amp; Resilience</b></p> <ul style="list-style-type: none"> <li>Multi-AZ HA deployment (MetroCluster)</li> <li>SnapShot &amp; SnapRestore</li> <li>SnapMirror</li> <li>SnapMirror Business Continuity (MetroCluster)</li> <li>SnapMirror Cloud</li> </ul>	<p><b>Access Protocols</b></p> <ul style="list-style-type: none"> <li>NFS –v3, v4, v4.1, v4.2</li> <li>SMB – v2, v3</li> <li>iSCSI</li> <li>Multi-protocol access</li> </ul>
<p><b>Storage Efficiency</b></p> <ul style="list-style-type: none"> <li>Deduplication &amp; Compression</li> <li>Compaction</li> <li>Thin provisioning</li> <li>Data Tiering (Fabric Pool)</li> </ul>	<p><b>Security &amp; Compliance</b></p> <ul style="list-style-type: none"> <li>Fpolicy &amp; Vscan</li> <li>Active Directory integration</li> <li>LDAP &amp; Kerberos</li> <li>Certificate based authentication</li> </ul>

**NetApp BlueXP** enables you to manage all of your storage and data assets from a single control plane/interface.

You can use BlueXP to create and administer cloud storage (for example, Cloud Volumes ONTAP and Azure NetApp Files), to move, protect, and analyze data, and to control many on-prem and edge storage devices.

**NetApp Astra Trident** is a CSI Compliant Storage Orchestrator that enable quick and easy consumption of persistent storage backed by a variety of the above-mentioned NetApp storage options. It is an open-source software maintained and supported by NetApp.

## Astra Trident CSI feature highlights



<p><b>CSI specific</b></p> <ul style="list-style-type: none"> <li>CSI NetApp® Snapshot™ copies and volume creation from CSI Snapshot copies</li> <li>CSI topology</li> <li>Volume expansion</li> </ul>	<p><b>Security</b></p> <ul style="list-style-type: none"> <li>Dynamic-export policy management</li> <li>iSCSI initiator-groups dynamic management</li> <li>iSCSI bidirectional CHAP</li> </ul>
<p><b>Control</b></p> <ul style="list-style-type: none"> <li>Storage and performance consumption</li> <li>Monitoring</li> <li>Volume Import</li> <li>Cross Namespace Volume Access</li> </ul>	<p><b>Installation methods</b></p> <ul style="list-style-type: none"> <li>Binary</li> <li>Helm chart</li> <li>Operator</li> <li>GitOps</li> </ul>
<p><b>Choose your access mode</b></p> <ul style="list-style-type: none"> <li>RWO (ReadWriteOnce, i.e 1↔1)</li> <li>RWX (ReadWriteMany, i.e 1↔n)</li> <li>ROX (ReadOnlyMany)</li> <li>RWOP (ReadWriteOnce POD)</li> </ul>	<p><b>Choose your protocol</b></p> <ul style="list-style-type: none"> <li>NFS</li> <li>SMB</li> <li>iSCSI</li> </ul>

Business critical container workloads need more than just persistent volumes. Their data management requirements require protection and migration of the application kubernetes objects as well.



Application data includes kubernetes objects in addition to the user data: Some examples are as follows:

- kubernetes objects such as pods specs, PVCs, deployments, services
- custom config objects such as config maps and secrets
- persistent data such as Snapshot copies, backups, clones
- custom resources such as CRs and CRDs

**NetApp Astra Control**, available as both fully-managed and self-managed software, provides orchestration for robust application data management. Refer to the [Astra documentation](#) for additional details on the Astra family of products.

This reference documentation provides validation of migration and protection of container-based applications, deployed on RedHat OpenShift container platform, using NetApp Astra Control Center. In addition, the solution provides high-level details for the deployment and the use of Red Hat Advanced Cluster Management (ACM) for managing the container platforms. The document also highlights the details for the integration of NetApp storage with Red Hat OpenShift container platforms using Astra Trident CSI provisioner. Astra Control Center is deployed on the hub cluster and is used to manage the container applications and their persistent storage lifecycle. Finally, it provides a solution for replication and failover and fail-back for container workloads on managed Red Hat OpenShift clusters in AWS (ROSA) using Amazon FSx for NetApp ONTAP (FSxN) as persistent storage.

## Value propositions of NetApp Hybrid Multicloud solutions for Red Hat OpenShift Container workloads

Most customers do not just start out building Kubernetes based environments without any existing infrastructure. Perhaps they are a traditional IT shop running most of their enterprise applications on virtual machines (in large VMware environments for example). Then they start building small container-based environments to satisfy the needs of their modern application development teams. These initiatives usually start small and begin to become more pervasive as the teams learn these new technologies and skills, and begin to recognize the many benefits of adopting them.

The good news for customers is that NetApp can serve the needs of both environments. This set of solutions for hybrid multicloud with Red Hat OpenShift will empower NetApp customers to adopt modern cloud technologies and services without having to overhaul their entire infrastructure and organization. Whether customer applications and data are hosted on-premises, in cloud, run on virtual machines, or on containers, NetApp can provide consistent data management, protection, security, and portability. With these new solutions, the same value NetApp has delivered in on-premises data center environments for decades will be available across the enterprise entire data horizon, without requiring significant investment to retool, acquire new skills, or build new teams. NetApp is positioned well to help customers solve these business challenges regardless of what phase of their cloud journey they are in.

NetApp Hybrid Multi-Cloud with Red Hat Openshift:

- Gives customers validated designs and practices which demonstrate the best ways for customers to manage, protect, secure, and migrate their data and applications when using Red Hat OpenShift with

NetApp based storage solutions.

- Present best practices for customers running Red Hat OpenShift with NetApp storage in VMware environments, bare metal infrastructure, or a combination of both.
- Demonstrate strategies and options for both on-prem and cloud environments, as well as hybrid environments where both are used.

## **Supported Solutions of NetApp Hybrid Multicloud for Red Hat OpenShift Container workloads**

The solution tests and validates Migration & Centralized Data Protection with OpenShift container platform (OCP), OpenShift Advanced Cluster Manager (ACM), NetApp ONTAP, NetApp BlueXP and NetApp Astra Control Center (ACC).

For this solution, the following scenarios are tested and validated by NetApp. The solution is separated into multiple scenarios based on the following characteristics:

- on-premises
- cloud
  - self-managed OpenShift clusters and self-managed NetApp storage
  - provider-managed OpenShift clusters and provider-managed NetApp storage

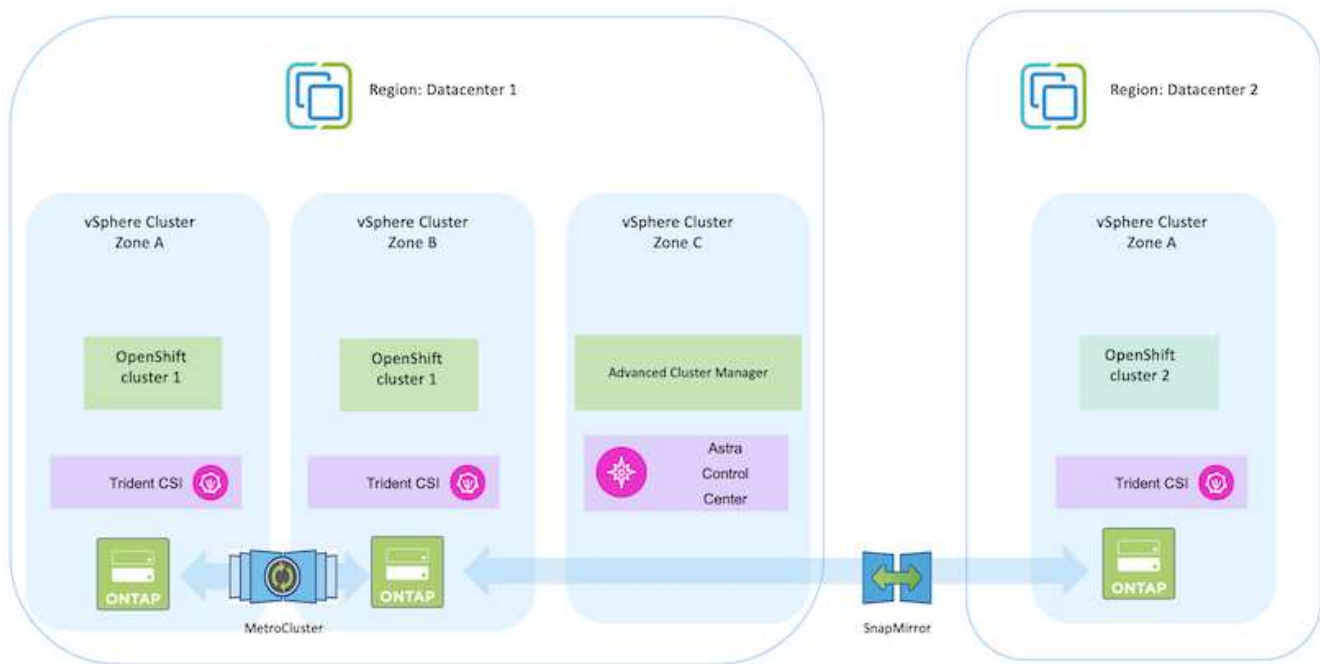
**We will be building out additional solutions and use cases in the future.**

### **Scenario 1: Data protection and migration within the on-premises environment using ACC**

#### **On-premises: self-managed OpenShift clusters and self-managed NetApp storage**

- Using ACC, create Snapshot copies, backups and restores for data protection.
- Using ACC, perform a SnapMirror replication of container applications.

#### **Scenario 1**



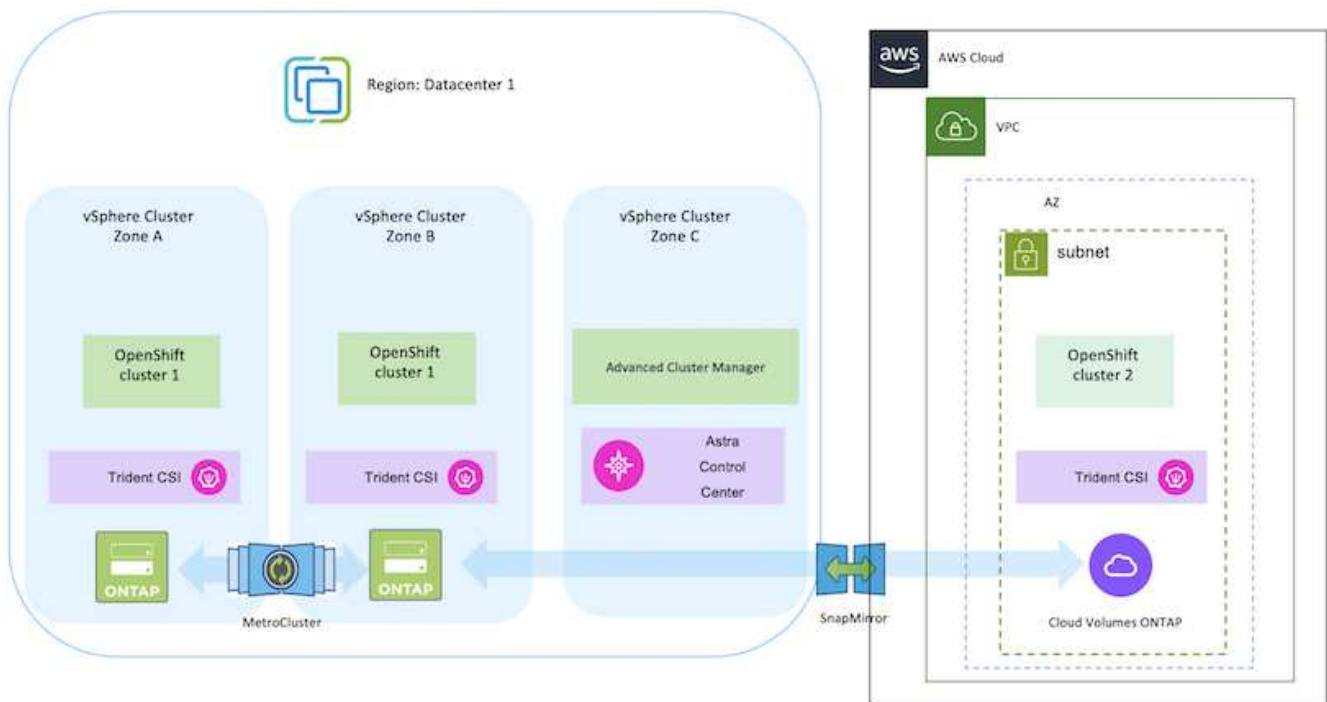
**Scenario 2: Data protection and migration from the on-premises environment to AWS environment using ACC**

**On-premises: Self-managed OpenShift cluster and self-managed storage**

**AWS Cloud: Self-managed OpenShift cluster and self-managed storage**

- Using ACC, perform backups and restores for data protection.
- Using ACC, perform a SnapMirror replication of container applications.

**Scenario 2**



### Scenario 3: Data protection and migration from the on-premises environment to AWS environment

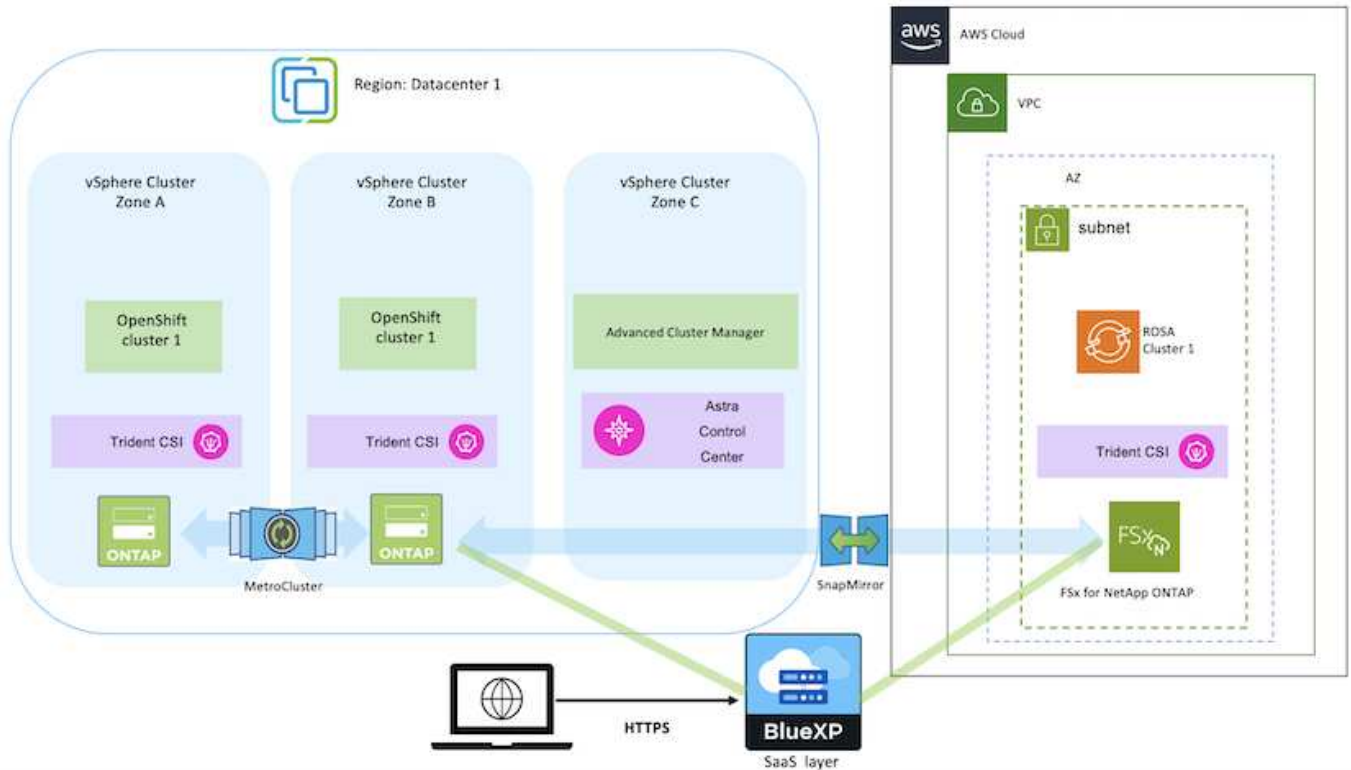
**On-premises: Self-managed OpenShift cluster and self-managed storage**

**AWS Cloud: Provider-managed OpenShift cluster (ROSA) and provider-managed storage (FSxN)**

- Using BlueXP, perform replication of persistent volumes (FSxN).
- Using OpenShift GitOps, recreate application metadata.

### Scenario 3

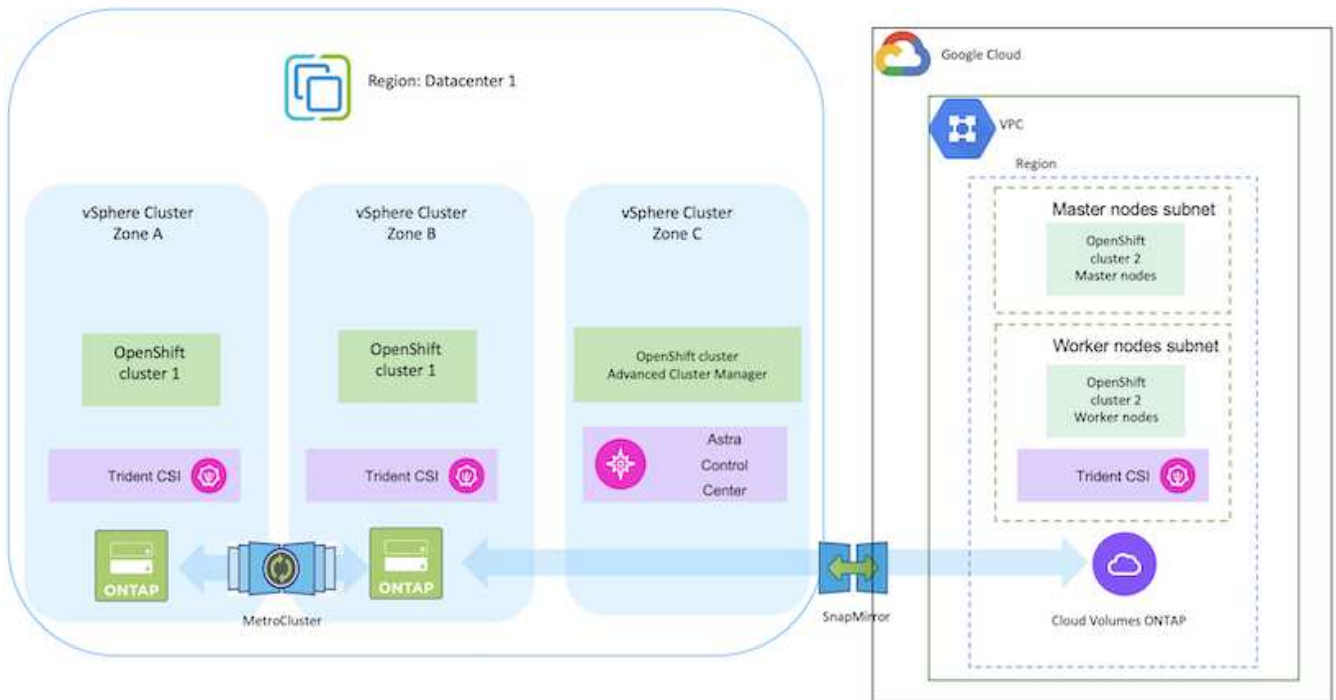




**Scenario 4: Data protection and migration from the on-premises environment to GCP environment using ACC**

**On-premises: Self-managed OpenShift cluster and self-managed storage**  
**Google Cloud: Self-managed OpenShift cluster and self-managed storage**

- Using ACC, perform backups and restores for data protection.
- Using ACC, perform a SnapMirror replication of container applications.



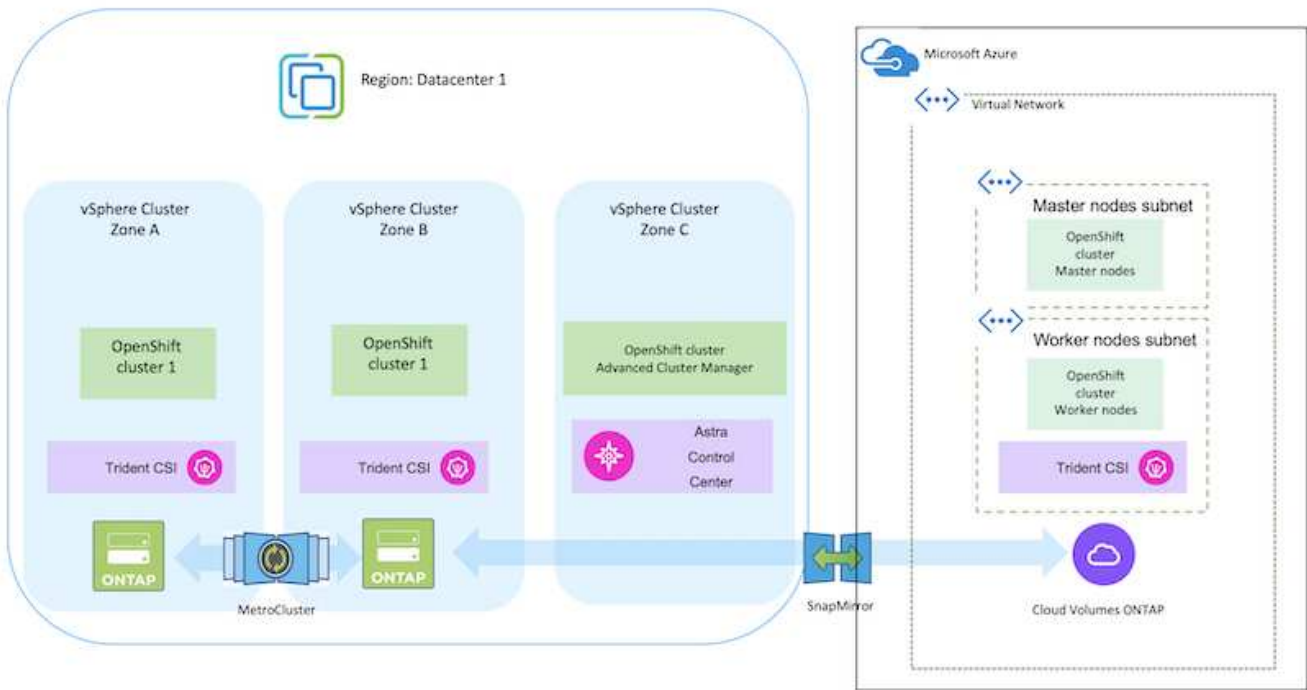
For considerations when using ONTAP in a MetroCluster configuration, refer [here](#).

**Scenario 5: Data protection and migration from the on-premises environment to Azure environment using ACC**

**On-premises: Self-managed OpenShift cluster and self-managed storage**

**Azure Cloud: Self-managed OpenShift cluster and self-managed storage**

- Using ACC, perform backups and restores for data protection.
- Using ACC, perform a SnapMirror replication of container applications.



For considerations when using ONTAP in a MetroCluster configuration, refer [here](#).

**Versions of various components used in the solution validation**

The solution tests and validates Migration & Centralized Data Protection with OpenShift container platform, OpenShift Advanced Cluster Manager, NetApp ONTAP, and NetApp Astra Control Center.

Scenarios 1, 2 and 3 of the solution were validated using the versions as shown in the table below:

Component	Version
VMware	vSphere Client version 8.0.0.10200 VMware ESXi, 8.0.0, 20842819
Hub Cluster	OpenShift 4.11.34

<b>Source and Destination Clusters</b>	OpenShift 4.12.9 on-premises and in AWS
<b>NetApp Astra Trident</b>	Trident Server and Client 23.04.0
<b>NetApp Astra Control Center</b>	ACC 22.11.0-82
<b>NetApp ONTAP</b>	ONTAP 9.12.1
<b>AWS FSx for NetApp ONTAP</b>	Single AZ

Scenario 4 of the solution was validated using the versions as shown in the table below:

<b>Component</b>	<b>Version</b>
<b>VMware</b>	vSphere Client version 8.0.2.00000 VMware ESXi, 8.0.2, 22380479
<b>Hub Cluster</b>	OpenShift 4.13.13
<b>Source and Destination Clusters</b>	OpenShift 4.13.12 on-premises and in Google Cloud
<b>NetApp Astra Trident</b>	Trident Server and Client 23.07.0
<b>NetApp Astra Control Center</b>	ACC 23.07.0-25
<b>NetApp ONTAP</b>	ONTAP 9.12.1
<b>Cloud Volumes ONTAP</b>	Single AZ, Single node,9.14.0

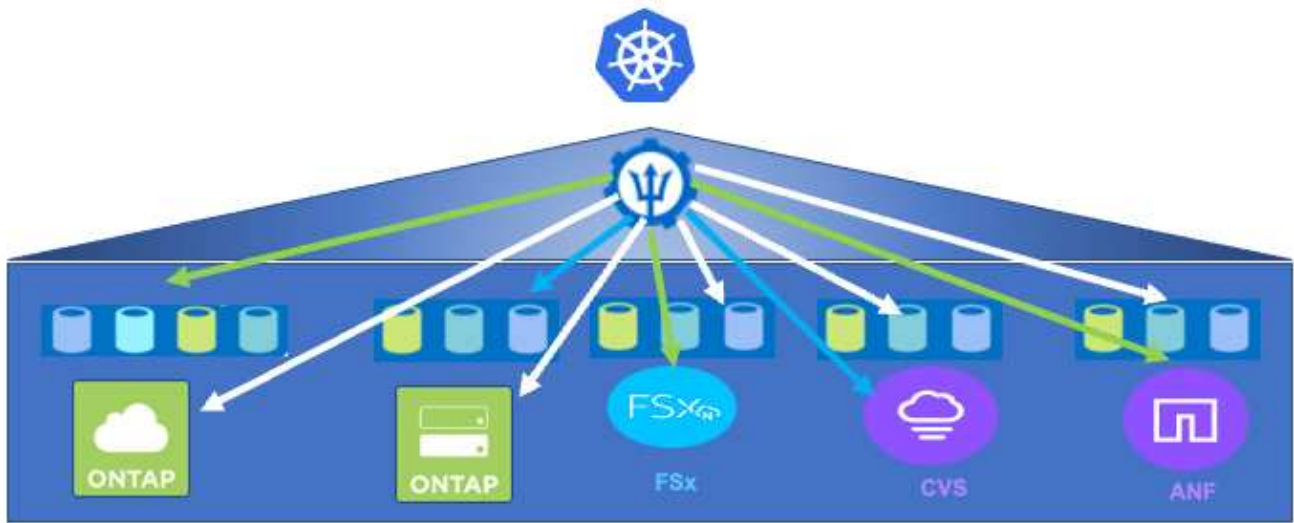
Scenario 5 of the solution was validated using the versions as shown in the table below:

<b>Component</b>	<b>Version</b>
<b>VMware</b>	vSphere Client version 8.0.2.00000 VMware ESXi, 8.0.2, 22380479
<b>Source and Destination Clusters</b>	OpenShift 4.13.25 on-premises and in Azure
<b>NetApp Astra Trident</b>	Trident Server and Client and Astra Control Provisioner 23.10.0
<b>NetApp Astra Control Center</b>	ACC 23.10
<b>NetApp ONTAP</b>	ONTAP 9.12.1
<b>Cloud Volumes ONTAP</b>	Single AZ, Single node,9.14.0

## Supported NetApp Storage integrations with Red Hat Open Shift Containers

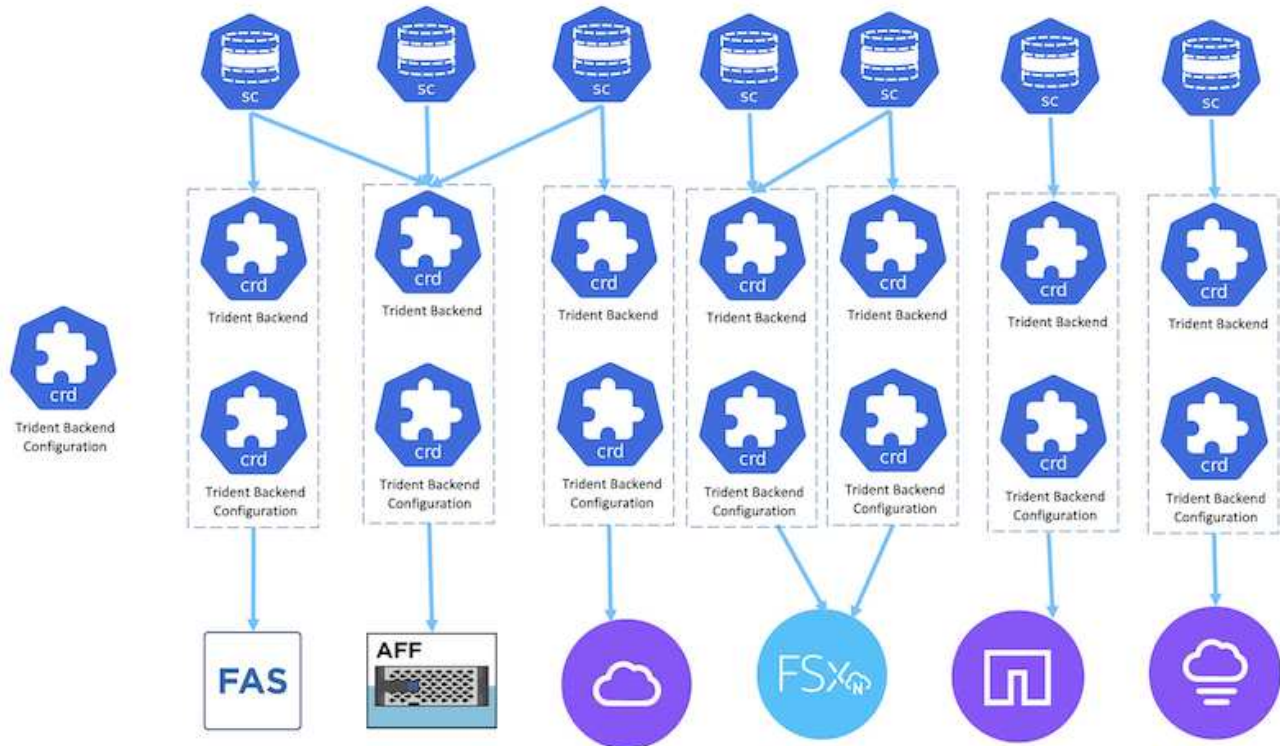
Whether the Red Hat Open Shift containers are running on VMware or in the hyperscalers, NetApp Astra Trident can be used as the CSI provisioner for the various types of backend NetApp storage that it supports.

The following diagram depicts the various backend NetApp storage that can be integrated with OpenShift clusters using NetApp Astra Trident.



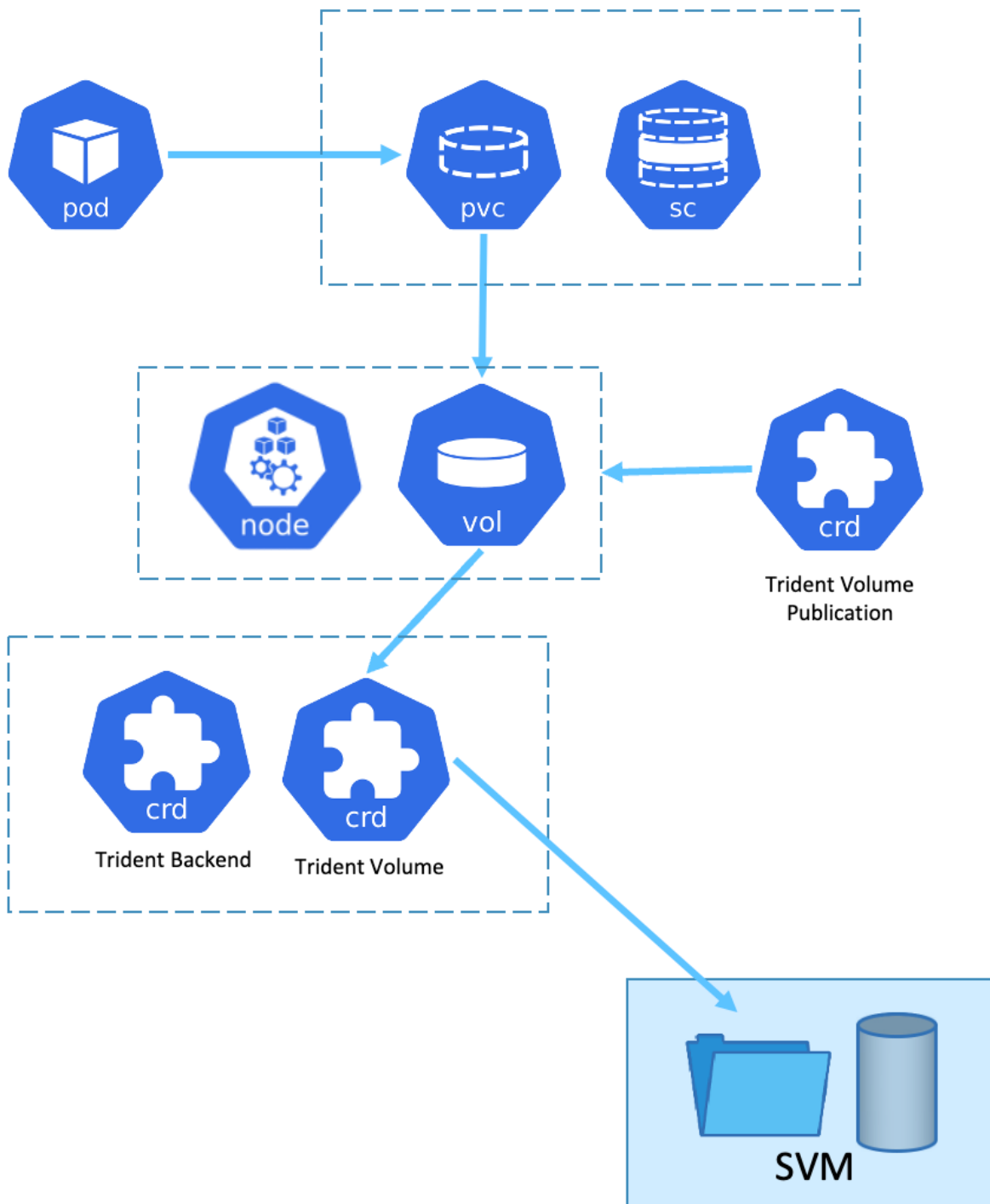
ONTAP Storage Virtual Machine (SVM) provides secure multi-tenancy. A Single OpenShift cluster can connect to single SVM or multiple SVMs or even to multiple ONTAP clusters. Storage class filters the backend storage based on parameters or by labels. Storage administrators define the parameters to connect to storage system using trident backend configuration. On successful connection establishment, it creates the trident backend and populates the information which the storage class can filter.

The relationship between the storageclass and backend is shown below.



Application owner requests persistent volume using storage class. The storage class filters the backend storage.

The relationship between the pod and backend storage is shown below.



## Container Storage Interface (CSI) Options

On vSphere environments, customers can pick VMware CSI driver and/or Astra Trident CSI to integrate with ONTAP. With VMware CSI, the persistent volumes are consumed as local SCSI disks, whereas with Trident, it is consumed with network.

As VMware CSI does not support RWX access modes with ONTAP, applications need to use Trident CSI if RWX mode is required. With FC based deployments, VMware CSI is preferred and SnapMirror Business Continuity (SMBC) provides zone level high availability.

## VMware CSI supports

- Core Block based datastores (FC, FCoE, iSCSI, NVMeoF)
- Core File based datastores (NFS v3, v4)
- vVol datastores (block and file)

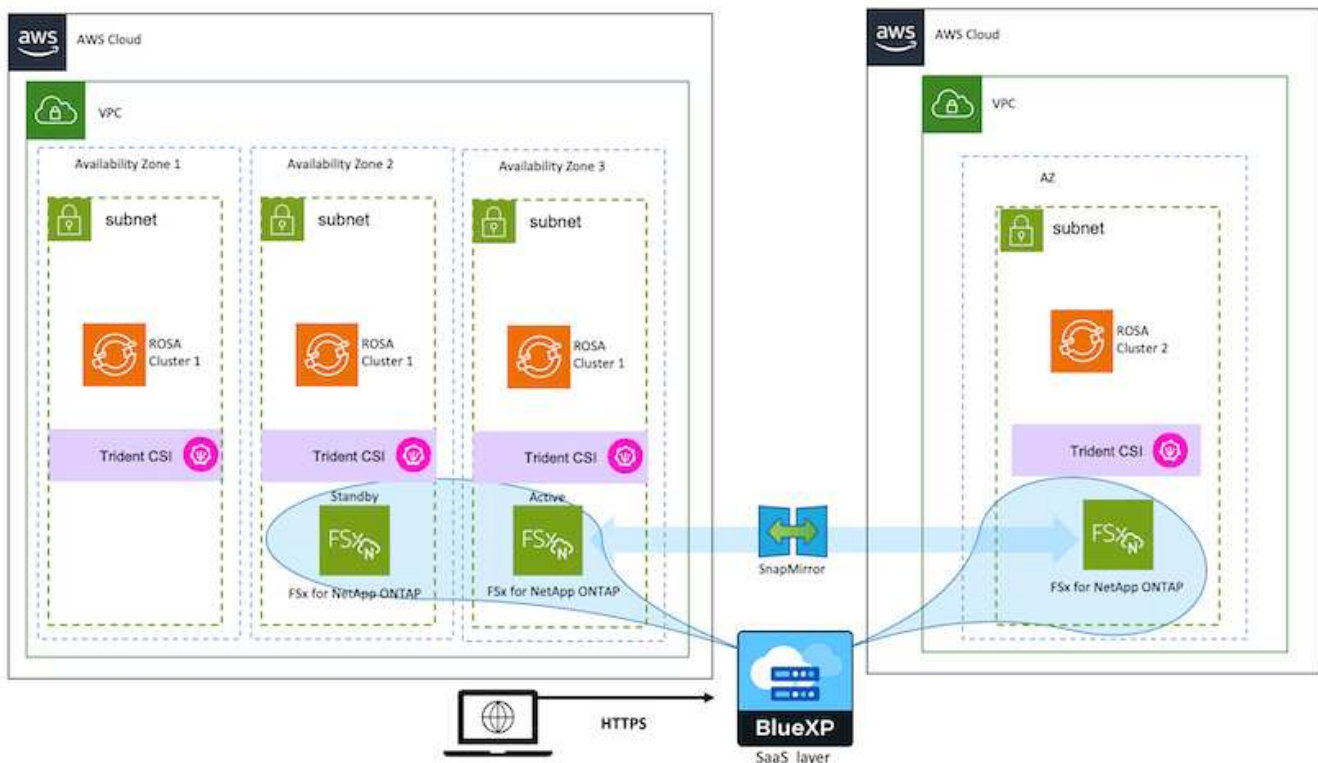
## Trident has following drivers to support ONTAP

- ontap-san (dedicated volume)
- ontap-san-economy (shared volume)
- ontap-nas (dedicated volume)
- ontap-nas-economy (shared volume)
- ontap-nas-flexgroup (dedicated large scale volume)

For both VMware CSI and Astra Trident CSI, ONTAP supports nconnect, session trunking, kerberos, etc. for NFS and multipathing, chap authentication, etc. for block protocols.

In AWS, FSx for NetApp ONTAP (FSxN) can be deployed in single Availability Zone (AZ) or in Multi AZ. For production workloads that requires high availability, multi-AZ provides zonal level fault tolerance and has better NVMe read cache compared to single AZ. For more info, check [AWS performance guidelines](#).

To save cost on disaster recovery site, single AZ FSx ONTAP can be utilized.



For number of SVMs that are supported by FSx ONTAP, refer [managing FSx ONTAP storage virtual machine](#)

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## ONTAP feature highlights



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<b>Choose your access mode</b> <ul style="list-style-type: none"><li>• RWO (<i>ReadWriteOnce</i>, i.e 1↔1)</li><li>• RWX (<i>ReadWriteMany</i>, i.e 1↔n)</li><li>• ROX (<i>ReadOnlyMany</i>)</li><li>• RWOP (<i>ReadWriteOnce</i> POD)</li></ul>	<b>Choose your protocol</b> <ul style="list-style-type: none"><li>• NFS</li><li>• SMB</li><li>• iSCSI</li></ul>

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## NetApp Solution with Red Hat OpenShift Container platform workloads on VMware

If customers have a need to run their modern containerized applications on infrastructure in their private data centers, they can do so. They should plan and deploy the Red Hat OpenShift container platform (OCP) for a successful production-ready environment for deploying their container workloads. Their OCP clusters can be deployed on VMware or bare metal.

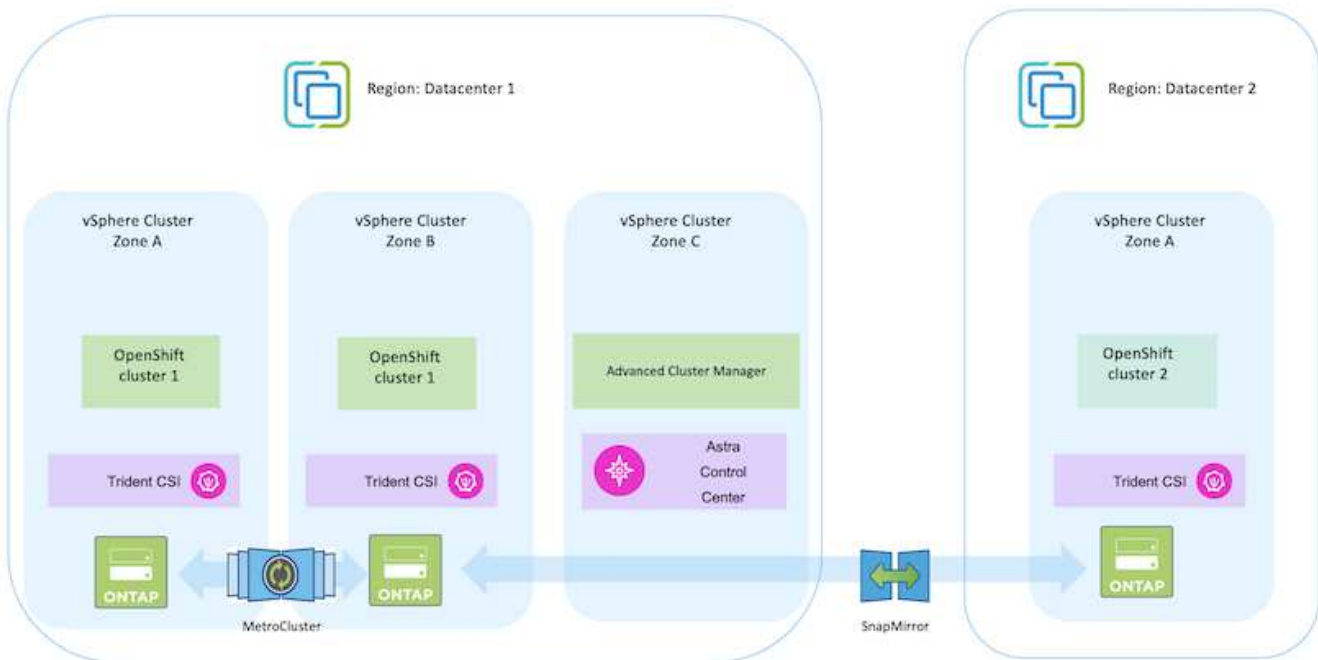
NetApp ONTAP storage delivers data protection, reliability, and flexibility for container deployments. Astra Trident serves as the dynamic storage provisioner to consume persistent ONTAP storage for customers' stateful applications. Astra Control Center can be used to orchestrate the many data management requirements of stateful applications such as data protection, migration, and business continuity.

With VMware vSphere, NetApp ONTAP tools provides a vCenter Plugin which can be utilized to provision datastores. Apply tags and use it with OpenShift for storing the node configuration and data. NVMe based storage provides lower latency and high performance.

This solution provides details for data protection and migration of container workloads using Astra Control Center. For this solution, the container workloads are deployed on Red Hat OpenShift clusters on vSphere within the on-premises environment.

NOTE: We will provide a solution for container workloads on OpenShift clusters on bare metal in the future.

### Data protection and migration solution for OpenShift Container workloads using Astra Control Center



### Deploy and configure the Red Hat OpenShift Container platform on VMware

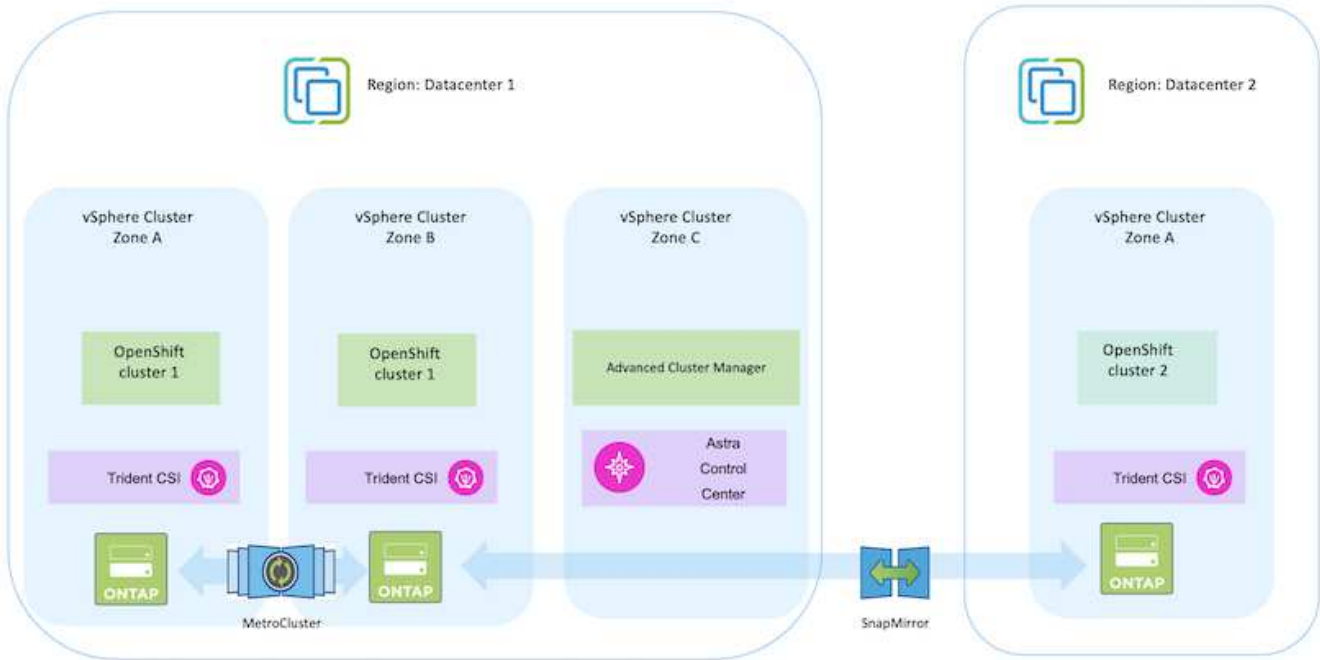
This section describes a high-level workflow of how to set up and manage OpenShift clusters and manage stateful applications on them. It shows the use of NetApp ONTAP storage arrays with the help of Astra Trident to provide persistent volumes. Details are

provided about the use of Astra Control Center to perform data protection and migration activities for the stateful applications.



There are several ways of deploying Red Hat OpenShift Container platform clusters. This high-level description of the setup provides documentation links for the specific method that was used. You can refer to the other methods in the relevant links provided in the [resources section](#).

Here is a diagram that depicts the clusters deployed on VMware in a data center.



The setup process can be broken down into the following steps:

### Deploy and configure a CentOS VM

- It is deployed in the VMware vSphere environment.
- This VM is used for deploying some components such as NetApp Astra Trident and NetApp Astra Control Center for the solution.
- A root user is configured on this VM during installation.

## Deploy and configure an OpenShift Container Platform cluster on VMware vSphere (Hub Cluster)

Refer to the instructions for the [Assisted deployment](#) method to deploy an OCP cluster.



Remember the following:

- Create ssh public and private key to provide to the installer. These keys will be used to login to the master and worker nodes if needed.
- Download the installer program from the assisted installer. This program is used to boot the VMs that you create in the VMware vSphere environment for the master and worker nodes.
- VMs should have the minimum CPU, memory, and hard disk requirement. (Refer to the vm create commands on [this](#) page for the master and the worker nodes which provide this information)
- The diskUUID should be enabled on all VMs.
- Create a minimum of 3 nodes for master and 3 nodes for worker.
- Once they are discovered by the installer, turn on the VMware vSphere integration toggle button.

### Install Advanced Cluster Management on the Hub cluster

This is installed using the Advanced Cluster Management Operator on the Hub Cluster. Refer to the instructions [here](#).

### Install an internal Red Hat Quay registry on the Hub Cluster.

- An internal registry is required to push the Astra image. A Quay internal registry is installed using the Operator in the Hub cluster.
- Refer to the instructions [here](#)

### Install two additional OCP clusters (Source and Destination)

- The additional clusters can be deployed using the ACM on the Hub Cluster.
- Refer to the instructions [here](#).

### Configure NetApp ONTAP storage

- Install an ONTAP cluster with connectivity to the OCP VMs in VMWare environment.
- Create an SVM.
- Configure NAS data lif to access the storage in SVM.

## Install NetApp Trident on the OCP clusters

- Install NetApp Trident on all three clusters: Hub, source, and destination clusters
- Refer to the instructions [here](#).
- Create a storage backend for ontap-nas .
- Create a storage class for ontap-nas.
- Refer to instructions [here](#).

## Install NetApp Astra Control Center

- NetApp Astra Control Center is installed using the Astra Operator on the Hub Cluster.
- Refer to the instructions [here](#).

Points to remember:

- \* Download NetApp Astra Control Center image from the support site.
- \* Push the image to an internal registry.
- \* Refer to instructions here.

## Deploy an Application on Source Cluster

Use OpenShift GitOps to deploy an application. (eg. Postgres, Ghost)

## Add the Source and Destination clusters into Astra Control Center.

After you add a cluster to Astra Control management, you can install apps on the cluster (outside of Astra Control) and then go to the Applications page in Astra Control to define the apps and their resources. Refer to [Start managing apps section of Astra Control Center](#).

The next step is to use the Astra Control Center for Data protection and Data migration from the source to the destination cluster.

## Data protection using Astra

This page shows the data protection options for Red Hat OpenShift Container based applications running on VMware vSphere using Astra Control Center (ACC).

As users take their journey of modernizing their applications with Red Hat OpenShift, a data protection strategy should be in place to protect them from accidental deletion or any other human errors. Often a protection strategy is also required for regulatory or compliance purposes to protect their data from a disaster.

The requirements of data protection varies from reverting back to a point in time copy to automatically failing over to a different fault domain without any human intervention. Many customers pick ONTAP as their preferred storage platform for their Kubernetes applications because of its rich features like multitenancy, multi-protocol, high performance and capacity offerings, replication and caching for multi-site locations, security and flexibility.

Data protection in ONTAP can be achieved using ad-hoc or policy controlled

- **Snapshot**

## - backup and restore

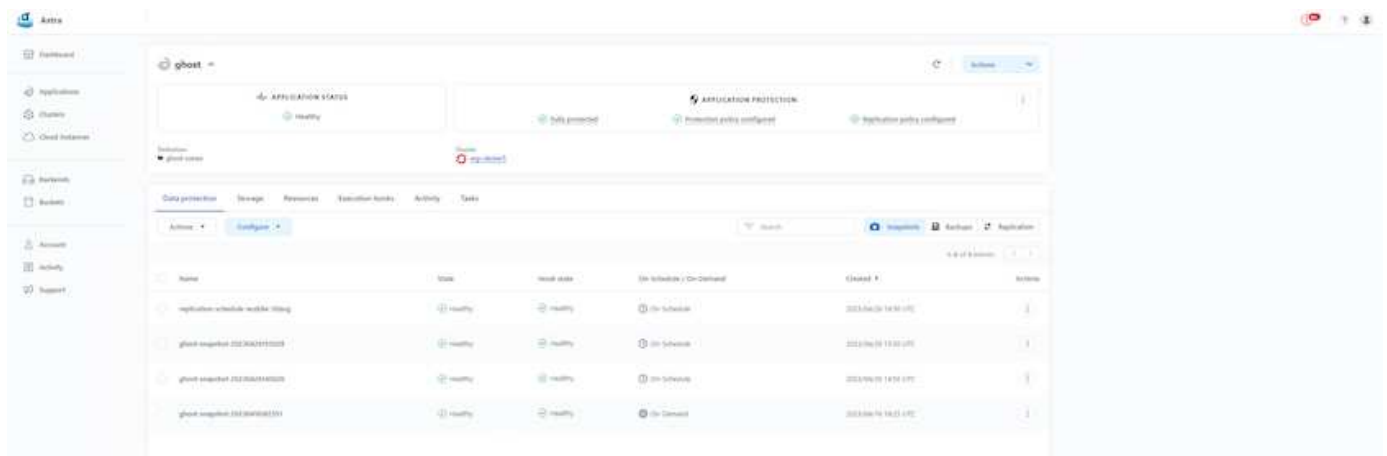
Both Snapshot copies and backups protect the following types of data:

- **The application metadata that represents the state of the application**
- **Any persistent data volumes associated with the application**
- **Any resource artifacts belonging to the application**

## Snapshot with ACC

A point in time copy of data can be captured using Snapshot with ACC. Protection policy defines the number of Snapshot copies to keep. Minimum schedule option available is hourly. Manual, on-demand Snapshot copies can be taken at any time and at shorter intervals than scheduled Snapshot copies. Snapshot copies are stored on the same provisioned volume as the app.

## Configuring Snapshot with ACC

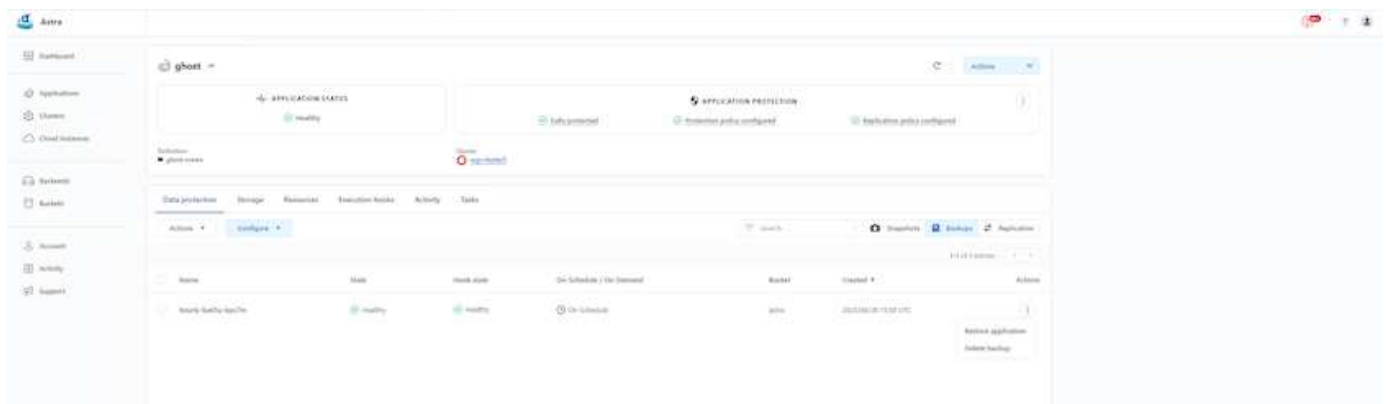


## Backup and Restore with ACC

A backup is based on a Snapshot. ACC can take Snapshot copies using CSI and perform backup using the point in time Snapshot copy. The backup is stored in an external object store (any s3 compatible including ONTAP S3 at a different location). Protection policy can be configured for scheduled backups and the number of backup versions to keep. The minimum RPO is one hour.

## Restoring an application from a backup using ACC

ACC restores application from the S3 bucket where the backups are store.



## Application specific execution hooks

In addition, execution hooks can be configured to run in conjunction with a data protection operation of a managed app. Even though storage array level data protection features are available, often additional steps are needed to make backups and restores, application consistent. The app-specific additional steps could be:

- before or after a Snapshot copy is created.
- before or after a backup is created.
- after restoring from a Snapshot copy or backup.

Astra Control can execute these app-specific steps coded as custom scripts called execution hooks.

[NetApp Verda GitHub project](#) provides execution hooks for popular cloud-native applications to make protecting applications straightforward, robust, and easy to orchestrate. Feel free to contribute to that project if you have enough information for an application that is not in the repository.

### Sample execution hook for pre-Snapshot of a redis application.

**Edit execution hook**

**HOOK DETAILS**

Operation: Pre-snapshot

Hook arguments (optional): pre

Hook name: redis-pre-snapshot

**CONTAINER IMAGES**

Apply to all container images

Use a regular expression to target container images for the hook.

Container image names to match: redis

**SCRIPT**

+ Add

Search

Name
<input type="radio"/> mariadb_mysql.sh
<input type="radio"/> postgresql.sh
<input checked="" type="radio"/> redis_hook.sh

Cancel Save

**EXECUTION HOOKS**

Execution hooks allow Astra Control to execute your own custom scripts before or after a snapshot.

Read more in [Manage application execution hooks](#)

## Replication with ACC

For regional protection or for a low RPO and RTO solution, an application can be replicated to another Kubernetes instance running at a different site, preferably in another region. ACC utilizes ONTAP async SnapMirror with RPO as low as 5 minutes. Replication is done by replicating to ONTAP and then a fail over

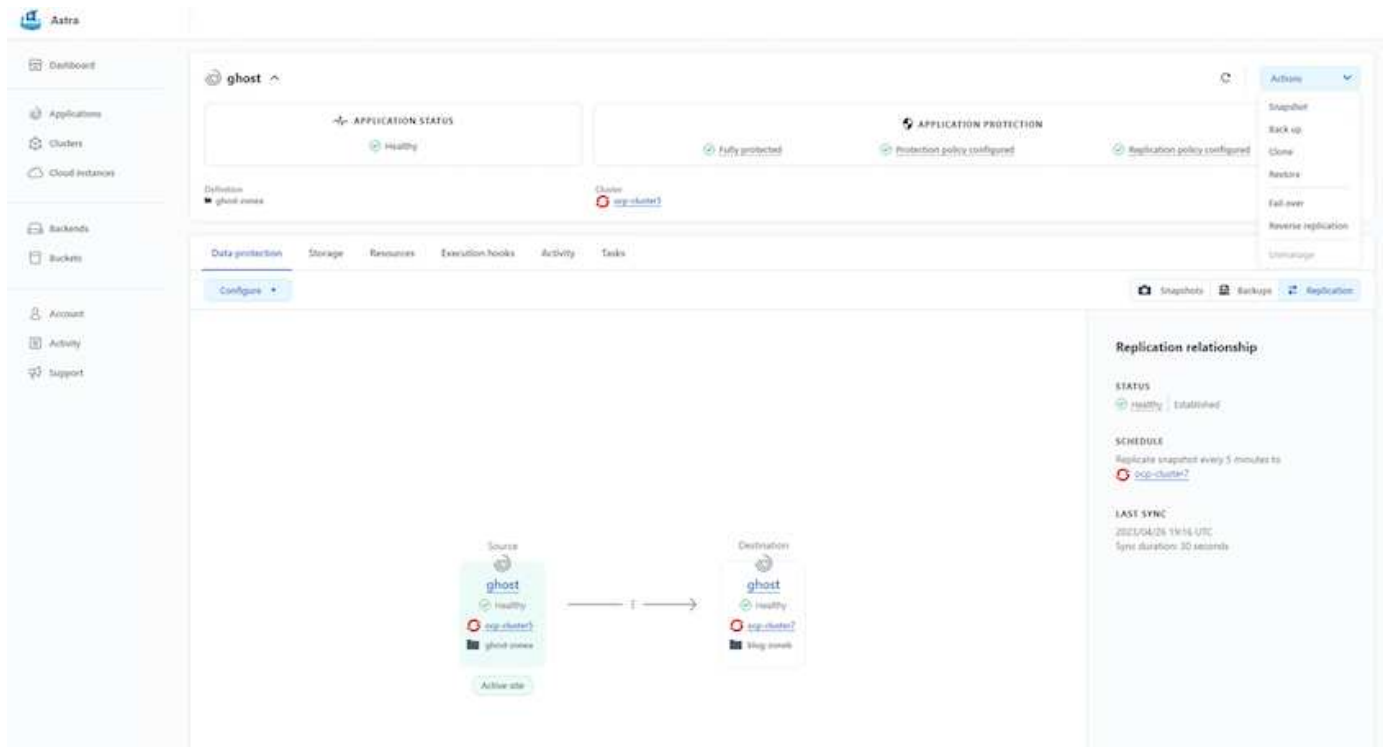
creates the Kubernetes resources in the destination cluster.



Note that replication is different from the backup and restore where the backup goes to S3 and restore is performed from S3. Refer [xref:./rhhc/ here](#) to get additional details about the differences between the two types of data protection.

Refer [here](#) for SnapMirror setup instructions.

### SnapMirror with ACC



san-economy and nas-economy storage drivers do not support replication feature. Refer [here](#) for additional details.

### Demo video:

[Demonstration video of disaster recovery with Astra Control Center](#)

[Data protection with Astra Control Center](#)

### Business Continuity with MetroCluster

Most of our hardware platform for ONTAP has high availability features to protect from device failures avoiding the need to perform disaster recovery. But to protect from fire or any other disaster and to continue the business with zero RPO and low RTO, often a MetroCluster solution is used.

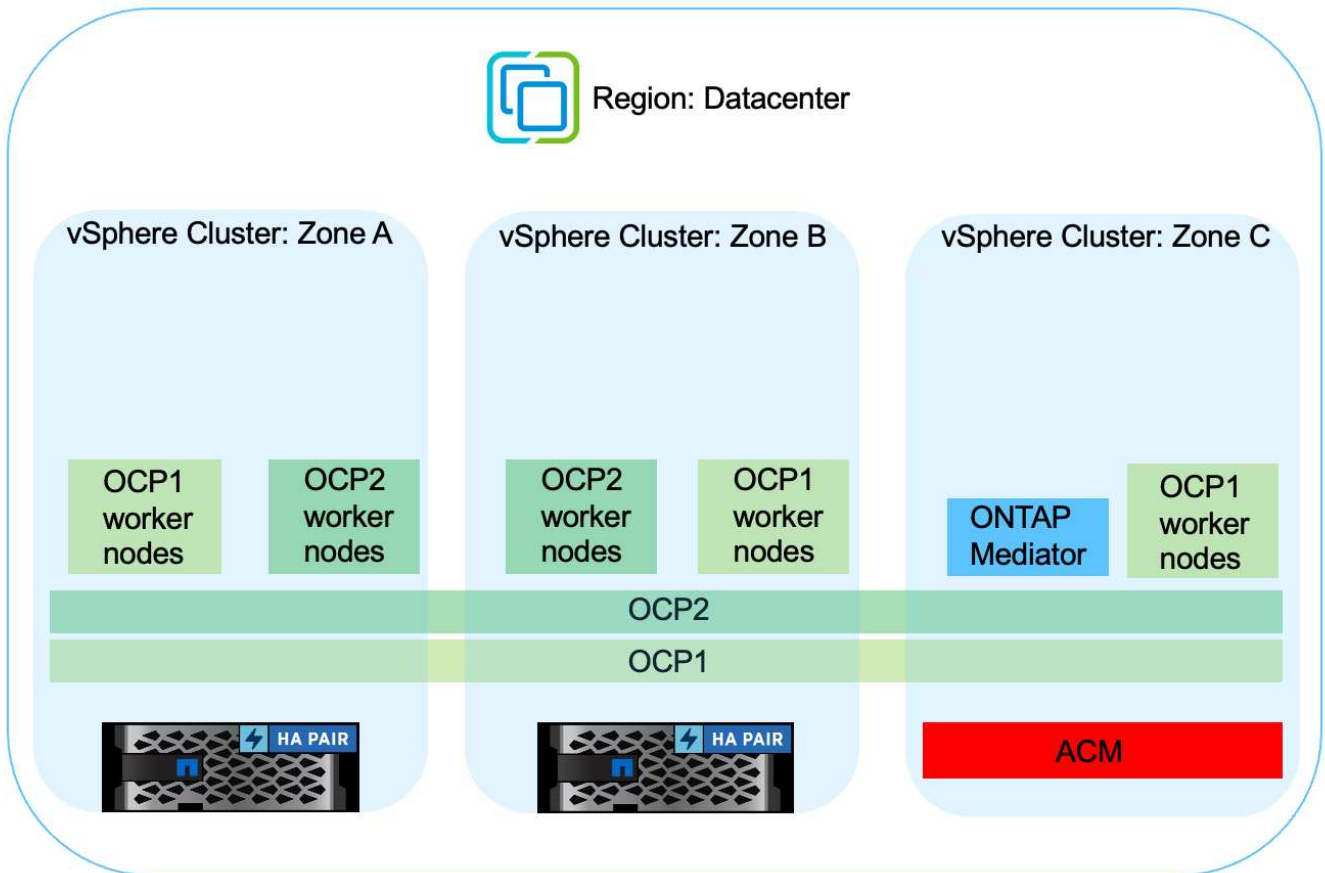
Customers who currently have an ONTAP system can extend to MetroCluster by adding supported ONTAP systems within the distance limitations for providing zone level disaster recovery.

Astra Trident, the CSI (Container Storage Interface) supports NetApp ONTAP including MetroCluster configuration as well as other options like Cloud Volumes ONTAP, Azure NetApp Files, AWS FSx for NetApp ONTAP, etc. Astra Trident provides five storage driver options for ONTAP and all are supported for MetroCluster configuration. Refer [here](#) for additional details about ONTAP storage drivers supported by Astra



Trident.

The MetroCluster solution requires layer 2 network extension or capability to access the same network address from both fault domains. Once MetroCluster configuration is in place, the solution is transparent to application owners as all the volumes in the MetroCluster svm are protected and get the benefits of SyncMirror (zero RPO).



For Trident Backend Configuration (TBC), do not specify the dataLIF and SVM when using MetroCluster configuration. Specify SVM management IP for managementLIF and use vsadmin role credentials.

Details on Astra Control Center Data Protection features are available [here](#)

## Data migration using Astra Control Center

This page shows the data migration options for container workloads on Red Hat OpenShift clusters with Astra Control Center (ACC).

Kubernetes Applications are often required to be moved from one environment to another. To migrate an application along with its persistent data, NetApp ACC can be utilized.

### Data Migration between different Kubernetes environment

ACC supports various Kubernetes flavors including Google Anthos, Red Hat OpenShift, Tanzu Kubernetes Grid, Rancher Kubernetes Engine, Upstream Kubernetes, etc. For additional details, refer [here](#).

To migrate application from one cluster to another, you can use one of the following features of ACC:

- replication
- backup and restore
- clone

Refer to the [data protection section](#) for the **replication and backup and restore** options.

Refer [here](#) for additional details about **cloning**.



Astra Replication feature is only supported with Trident Container Storage Interface (CSI). However, replication is not supported by nas-economy & san-economy drivers.

## Performing data replication using ACC

The screenshot displays the Astra console interface for configuring data replication. The main view shows the 'ghost' application with a 'Healthy' status. Below this, there are sections for 'APPLICATION PROTECTION' (Fully protected) and 'APPLICATION POLICY CONFIGURED' (Protection policy configured and Replication policy configured). A 'Replication relationship' panel on the right shows the status as 'healthy - Established', a schedule of 'Replicate snapshots every 5 minutes to ocp-cluster?', and a last sync time of '2023/04/26 19:16 UTC' with a duration of 30 seconds. The central diagram illustrates the replication flow from a 'Source' cluster (ghost) to a 'Destination' cluster (ghost).

## NetApp Hybrid Multicloud solutions for Red Hat OpenShift Container workloads

NetApp is seeing a significant increase in customers modernizing their legacy enterprise applications and building new applications using containers and orchestration platforms built around Kubernetes. Red Hat OpenShift Container Platform is one example that we see adopted by many of our customers.

### Overview

As more and more customers begin adopting containers within their enterprises, NetApp is perfectly positioned to help serve the persistent storage needs of their stateful applications and classic data management needs such as data protection, data security, and data migration. However, these needs are met using different

strategies, tools, and methods.

**NetApp ONTAP** based storage options listed below, deliver security, data protection, reliability, and flexibility for containers and Kubernetes deployments.

- Self-managed storage in on-premises:
  - NetApp Fabric Attached Storage (FAS), NetApp All Flash FAS Arrays (AFF), NetApp All SAN Array (ASA) and ONTAP Select
- Provider-managed storage in on-premises:
  - NetApp Keystone provides Storage as a Service (STaaS)
- Self-managed storage in the cloud:
  - NetApp Cloud Volumes ONTAP(CVO) provide self managed storage in the hyperscalers
- Provider-managed storage in the cloud:
  - Cloud Volumes Service for Google Cloud (CVS), Azure NetApp Files (ANF), Amazon FSx for NetApp ONTAP offer fully managed storage in the hyperscalers

## ONTAP feature highlights



<p><b>Storage Administration</b></p> <ul style="list-style-type: none"><li>• Multi-tenancy</li><li>• FlexVol &amp; FlexGroup</li><li>• LUN</li><li>• Quotas</li><li>• ONTAP CLI &amp; API</li><li>• System Manager &amp; BlueXP</li></ul>	<p><b>Performance &amp; Scalability</b></p> <ul style="list-style-type: none"><li>• FlexCache</li><li>• FlexClone</li><li>• nconnect, session trunking, multipathing</li><li>• Scale-out clusters</li></ul>
<p><b>Availability &amp; Resilience</b></p> <ul style="list-style-type: none"><li>• Multi-AZ HA deployment (MetroCluster)</li><li>• SnapShot &amp; SnapRestore</li><li>• SnapMirror</li><li>• SnapMirror Business Continuity</li><li>• SnapMirror Cloud</li></ul>	<p><b>Access Protocols</b></p> <ul style="list-style-type: none"><li>• NFS –v3, v4, v4.1, v4.2</li><li>• SMB – v2, v3</li><li>• iSCSI</li><li>• Multi-protocol access</li></ul>
<p><b>Storage Efficiency</b></p> <ul style="list-style-type: none"><li>• Deduplication &amp; Compression</li><li>• Compaction</li><li>• Thin provisioning</li><li>• Data Tiering (Fabric Pool)</li></ul>	<p><b>Security &amp; Compliance</b></p> <ul style="list-style-type: none"><li>• Fpolicy &amp; Vscan</li><li>• Active Directory integration</li><li>• LDAP &amp; Kerberos</li><li>• Certificate based authentication</li></ul>

**NetApp BlueXP** enables you to manage all of your storage and data assets from a single control plane/interface.

You can use BlueXP to create and administer cloud storage (for example, Cloud Volumes ONTAP and Azure NetApp Files), to move, protect, and analyze data, and to control many on-prem and edge storage devices.

**NetApp Astra Trident** is a CSI Compliant Storage Orchestrator that enable quick and easy consumption of persistent storage backed by a variety of the above-mentioned NetApp storage options. It is an open-source software maintained and supported by NetApp.



## Astra Trident CSI feature highlights

<p style="text-align: center;"><b>CSI specific</b></p> <ul style="list-style-type: none"> <li>• CSI NetApp® Snapshot™ copies and volume creation from CSI Snapshot copies</li> <li>• CSI topology</li> <li>• Volume expansion</li> </ul>	<p style="text-align: center;"><b>Security</b></p> <ul style="list-style-type: none"> <li>• Dynamic-export policy management</li> <li>• iSCSI initiator-groups dynamic management</li> <li>• iSCSI bidirectional CHAP</li> </ul>
<p style="text-align: center;"><b>Control</b></p> <ul style="list-style-type: none"> <li>• Storage and performance consumption</li> <li>• Monitoring</li> <li>• Volume Import</li> <li>• Cross Namespace Volume Access</li> </ul>	<p style="text-align: center;"><b>Installation methods</b></p> <ul style="list-style-type: none"> <li>• Binary</li> <li>• Helm chart</li> <li>• Operator</li> <li>• GitOps</li> </ul>
<p style="text-align: center;"><b>Choose your access mode</b></p> <ul style="list-style-type: none"> <li>• RWO (<i>ReadWriteOnce</i>, i.e 1↔1)</li> <li>• RWX (<i>ReadWriteMany</i>, i.e 1↔n)</li> <li>• ROX (<i>ReadOnlyMany</i>)</li> <li>• RWOP (<i>ReadWriteOnce</i> POD)</li> </ul>	<p style="text-align: center;"><b>Choose your protocol</b></p> <ul style="list-style-type: none"> <li>• NFS</li> <li>• SMB</li> <li>• iSCSI</li> </ul>

Business critical container workloads need more than just persistent volumes. Their data management requirements require protection and migration of the application kubernetes objects as well.



Application data includes kubernetes objects in addition to the user data: Some examples are as follows:

- kubernetes objects such as pods specs, PVCs, deployments, services
- custom config objects such as config maps and secrets
- persistent data such as Snapshot copies, backups, clones
- custom resources such as CRs and CRDs

**NetApp Astra Control**, available as both fully-managed and self-managed software, provides orchestration for robust application data management. Refer to the [Astra documentation](#) for additional details on the Astra family of products.

This reference documentation provides validation of migration and protection of container-based applications, deployed on RedHat OpenShift container platform, using NetApp Astra Control Center. In addition, the solution provides high-level details for the deployment and the use of Red Hat Advanced Cluster Management (ACM) for managing the container platforms. The document also highlights the details for the integration of NetApp storage with Red Hat OpenShift container platforms using Astra Trident CSI provisioner. Astra Control Center is deployed on the hub cluster and is used to manage the container applications and their persistent storage lifecycle. Finally, it provides a solution for replication and failover and fail-back for container workloads on managed Red Hat OpenShift clusters in AWS (ROSA) using Amazon FSx for NetApp ONTAP (FSxN) as persistent storage.

## NetApp Solution with Red Hat OpenShift Container platform workloads in Hybrid Cloud

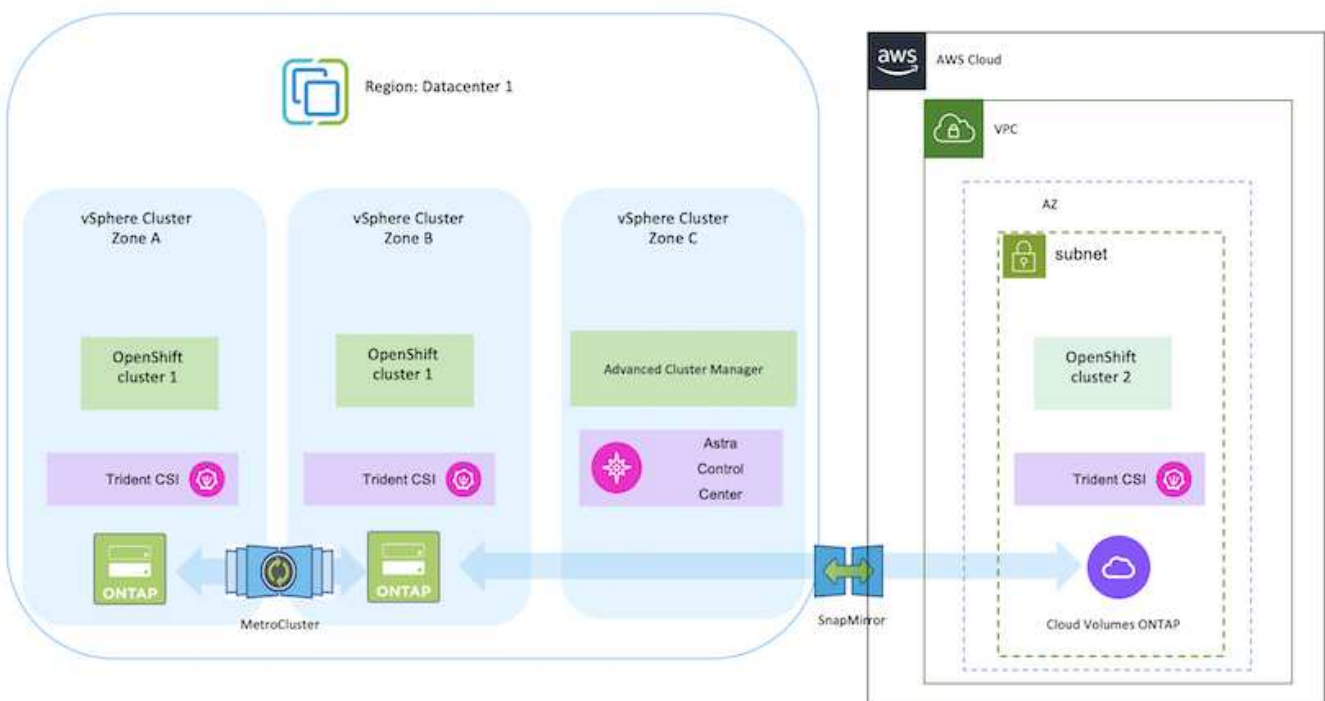
Customers may be at a point in their modernization journey when they are ready to move some select workloads or all workloads from their data centers to the cloud. They may choose to use self-managed OpenShift containers and self-managed NetApp storage in the cloud for various reasons. They should plan and deploy the Red Hat OpenShift

container platform (OCP) in the cloud for a successful production-ready environment for migrating their container workloads from their data centers. Their OCP clusters can be deployed on VMware or Bare Metal in their data centers and on AWS, Azure or Google Cloud in the cloud environment.

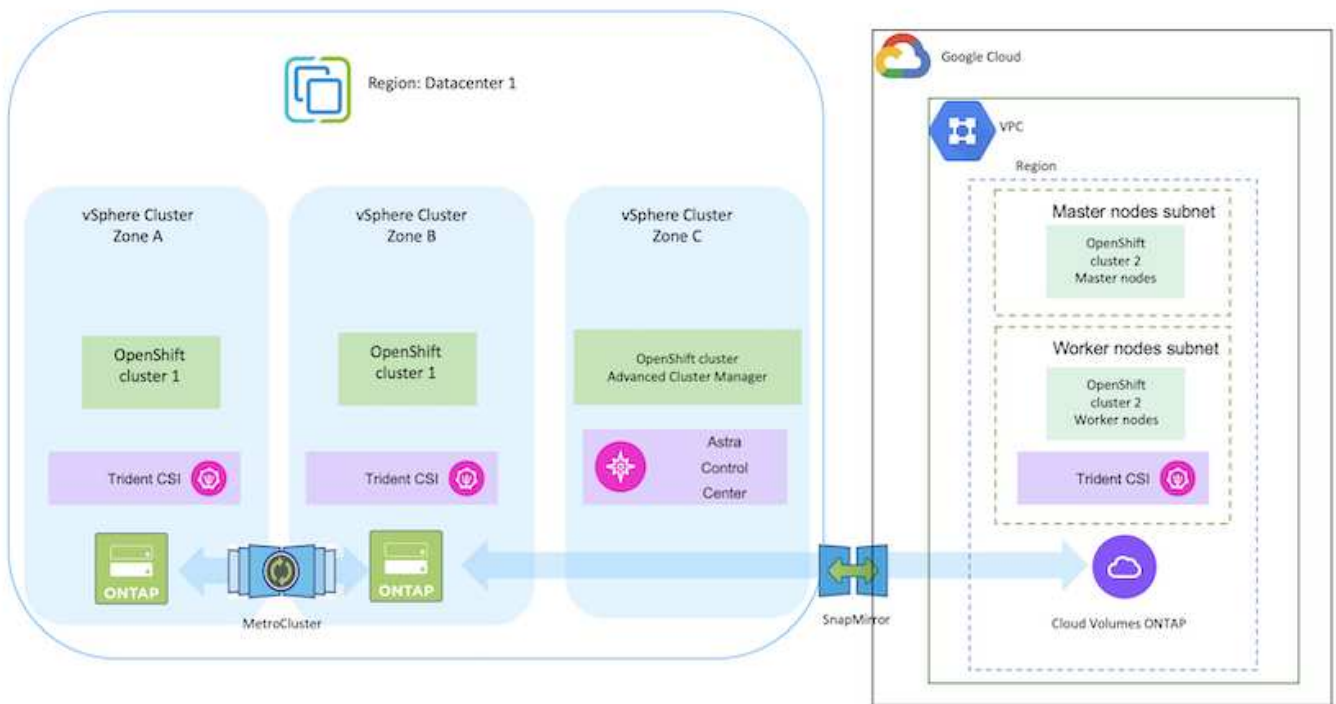
NetApp Cloud Volumes ONTAP storage delivers data protection, reliability, and flexibility for container deployments in AWS, Azure and in Google Cloud. Astra Trident serves as the dynamic storage provisioner to consume the persistent Cloud Volumes ONTAP storage for customers' stateful applications. Astra Control Center can be used to orchestrate the many data management requirements of stateful applications such as data protection, migration, and business continuity.

### Data protection and migration solution for OpenShift Container workloads in a hybrid cloud using Astra Control Center

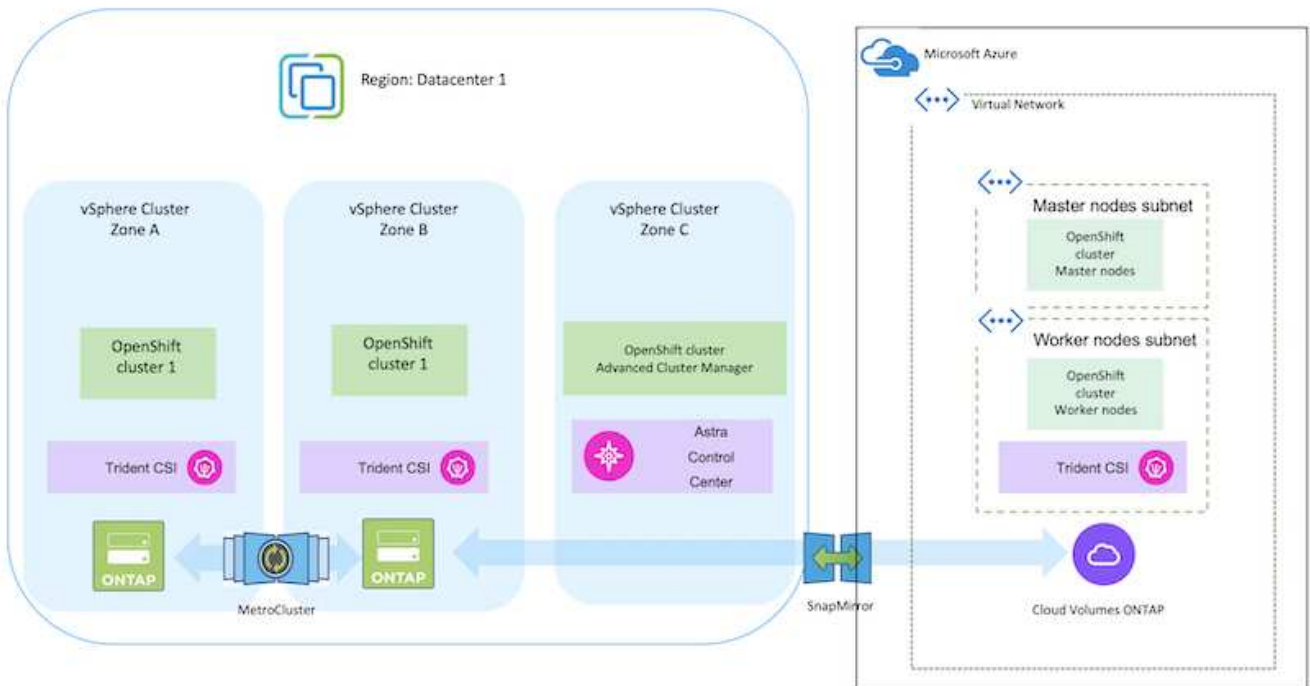
On-premises and AWS



On-premises and Google Cloud



On-premises and Azure Cloud



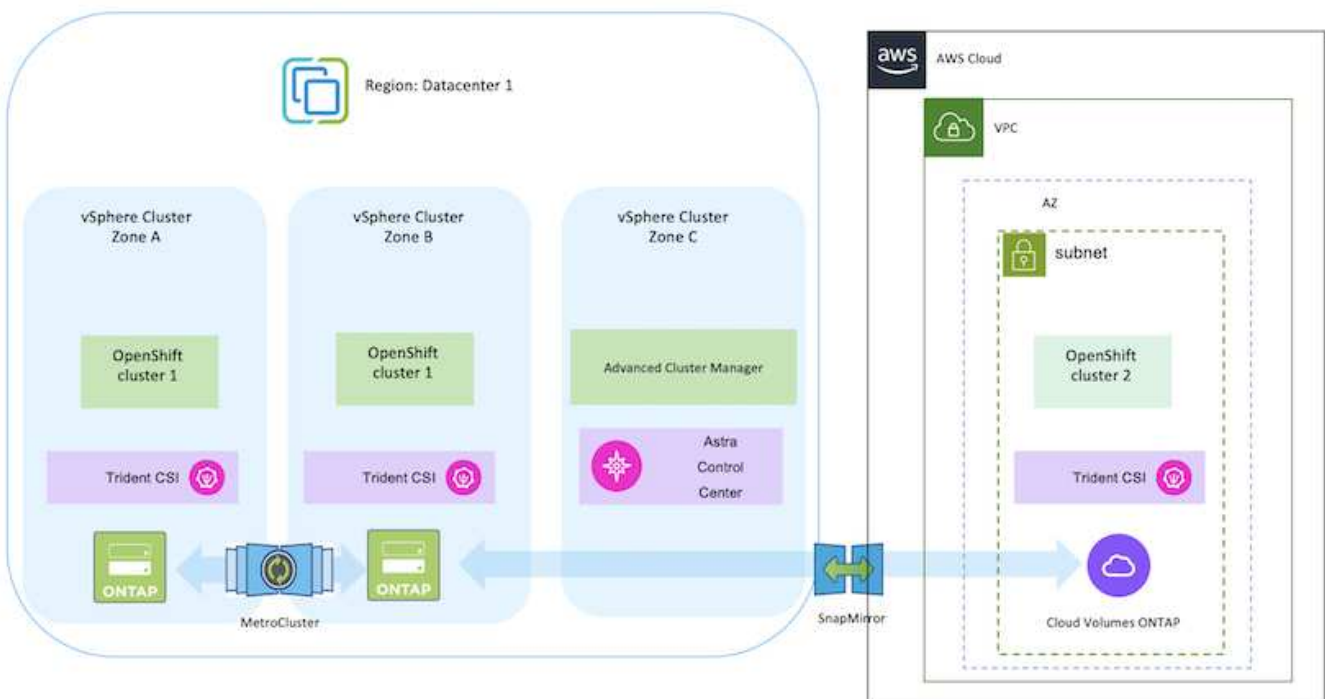
## Deploy and configure the Red Hat OpenShift Container platform on AWS

This section describes a high-level workflow of how to set up and manage OpenShift Clusters in AWS and deploy stateful applications on them. It shows the use of NetApp Cloud Volumes ONTAP storage with the help of Astra Trident to provide persistent volumes. Details are provided about the use of Astra Control Center to perform data protection and migration activities for the stateful applications.



There are several ways of deploying Red Hat OpenShift Container platform clusters on AWS. This high-level description of the setup provides documentation links for the specific method that was used. You can refer to the other methods in the relevant links provided in the [resources section](#).

Here is a diagram that depicts the clusters deployed on AWS and connected to the data center using a VPN.



The setup process can be broken down into the following steps:

## Install an OCP cluster on AWS from the Advanced Cluster Management.

- Create a VPC with a site-to-site VPN connection (using pfsense) to connect to the on-premises network.
- On-premises network has internet connectivity.
- Create 3 private subnets in 3 different AZs.
- Create a Route 53 private hosted zone and a DNS resolver for the VPC.

Create OpenShift Cluster on AWS from the Advanced Cluster Management (ACM) Wizard. Refer to instructions [here](#).



You can also create the cluster in AWS from the OpenShift Hybrid Cloud console. Refer [here](#) for instructions.



When creating the cluster using the ACM, you have the ability to customize the installation by editing the yaml file after filling in the details in the form view. After the cluster is created, you can ssh login to the nodes of the cluster for troubleshooting or additional manual configuration. Use the ssh key you provided during installation and the username core to login.

## Deploy Cloud Volumes ONTAP in AWS using BlueXP.

- Install the connector in on-premises VMware environment. Refer to instructions [here](#).
- Deploy a CVO instance in AWS using the connector. Refer to instructions [here](#).



The connector can also be installed in the cloud environment. Refer [here](#) for additional information.

## Install Astra Trident in the OCP Cluster

- Deploy Trident Operator using Helm.  
Refer to instructions [here](#)
- Create a backend and a storage class. Refer to instructions [here](#).

## Add the OCP cluster on AWS to the Astra Control Center.

Add the OCP cluster in AWS to Astra Control Center.

## Using CSI Topology feature of Trident for multi-zone architectures

Cloud providers, today, enable Kubernetes/OpenShift cluster administrators to spawn nodes of the clusters that are zone based. Nodes can be located in different availability zones within a region, or across various regions. To facilitate the provisioning of volumes for workloads in a multi-zone architecture, Astra Trident uses CSI Topology. Using the CSI Topology feature, access to volumes can be limited to a subset of nodes, based on regions and availability zones. Refer [here](#) for additional details.



Kubernetes supports two volume binding modes:

- When **VolumeBindingMode is set to Immediate** (default), Astra Trident creates the volume without any topology awareness. Persistent Volumes are created without having any dependency on the requesting pod's scheduling requirements.
- When **VolumeBindingMode set to WaitForFirstConsumer**, the creation and binding of a Persistent Volume for a PVC is delayed until a pod that uses the PVC is scheduled and created. This way, volumes are created to meet the scheduling constraints that are enforced by topology requirements.

Astra Trident storage backends can be designed to selectively provision volumes based on availability zones (Topology-aware backend). For StorageClasses that make use of such a backend, a volume would only be created if requested by an application that is scheduled in a supported region/zone. (Topology-aware StorageClass)

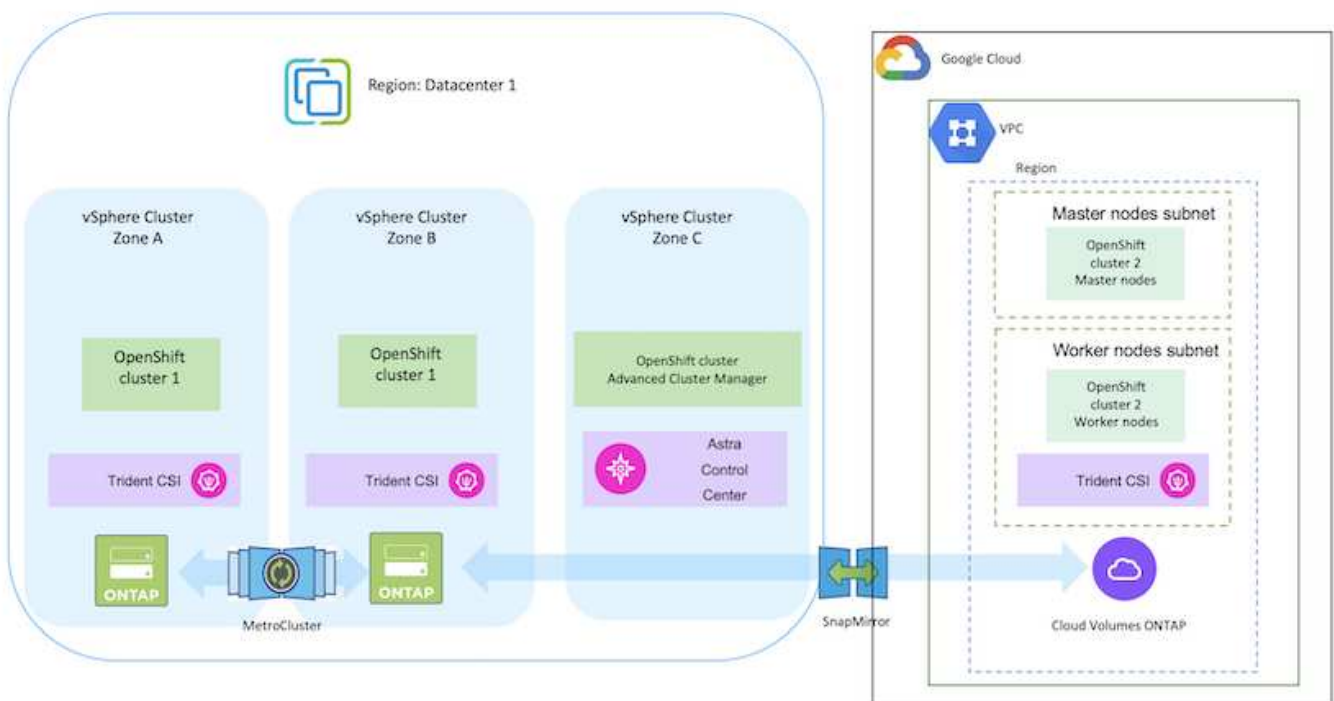
Refer [here](#) for additional details.



## Deploy and configure the Red Hat OpenShift Container platform on GCP

This section describes a high-level workflow of how to set up and manage OpenShift Clusters in GCP and deploy stateful applications on them. It shows the use of NetApp Cloud Volumes ONTAP storage with the help of Astra Trident to provide persistent volumes. Details are provided about the use of Astra Control Center to perform data protection and migration activities for the stateful applications.

Here is a diagram that shows the clusters deployed on GCP and connected to the data center using a VPN.



There are several ways of deploying Red Hat OpenShift Container platform clusters in GCP. This high-level description of the setup provides documentation links for the specific method that was used. You can refer to the other methods in the relevant links provided in the [resources section](#).



The setup process can be broken down into the following steps:

### Install an OCP cluster on GCP from the CLI.

- Ensure that you have met all the prerequisites stated [here](#).
- For the VPN connectivity between on-premises and GCP, a pfsense VM was created and configured. For instructions, see [here](#).
  - The remote gateway address in pfsense can be configured only after you have created a VPN gateway in Google Cloud Platform.
  - The remote network IP addresses for the Phase 2 can be configured only after the OpenShift cluster installation program runs and creates the infrastructure components for the cluster.
  - The VPN in Google Cloud can only be configured after the infrastructure components for the cluster are created by the installation program.
- Now install the OpenShift cluster on GCP.
  - Obtain the installation program and the pull secret and deploy the cluster following the steps provided in the documentation [here](#).
  - The installation creates a VPC network in Google Cloud Platform. It also creates a private zone in Cloud DNS and adds A records.
    - Use the CIDR block address of the VPC network to configure the pfsense and establish the VPN connection. Ensure firewalls are setup correctly.
    - Add A records in the DNS of the on-premises environment using the IP address in the A records of the Google Cloud DNS.
  - The installation of the cluster completes and will provide a kubeconfig file and username and password to login to the console of the cluster.

### Deploy Cloud Volumes ONTAP in GCP using BlueXP.

- Install a connector in Google Cloud. Refer to instructions [here](#).
- Deploy a CVO instance in Google Cloud using the connector. Refer to instructions [here](https://docs.netapp.com/us-en/bluexp-cloud-volumes-ontap/task-getting-started-gcp.html).

### Install Astra Trident in the OCP Cluster in GCP

- There are many methods to deploy Astra Trident as shown [here](#).
- For this project, Astra Trident was installed by deploying Astra Trident Operator manually using the instructions [here](#).
- Create backend and a storage classes. Refer to instructions [here](#).

## Add the OCP cluster on GCP to the Astra Control Center.

- Create a separate KubeConfig file with a cluster role that contains the minimum permissions necessary for a cluster to be managed by Astra Control. The instructions can be found [here](#).
- Add the cluster to Astra Control Center following the instructions [here](#)

## Using CSI Topology feature of Trident for multi-zone architectures

Cloud providers, today, enable Kubernetes/OpenShift cluster administrators to spawn nodes of the clusters that are zone based. Nodes can be located in different availability zones within a region, or across various regions. To facilitate the provisioning of volumes for workloads in a multi-zone architecture, Astra Trident uses CSI Topology. Using the CSI Topology feature, access to volumes can be limited to a subset of nodes, based on regions and availability zones. Refer [here](#) for additional details.



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Refer [here](#) for additional details.

## Demonstration Video

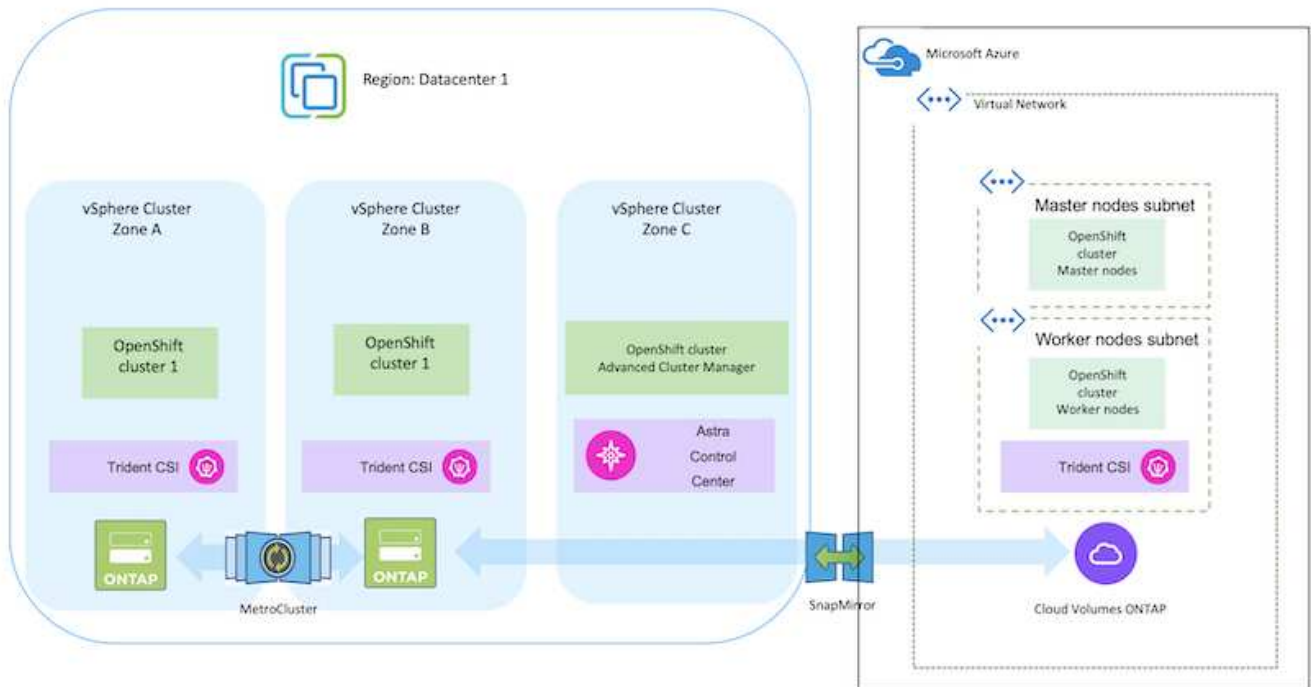
[OpenShift Cluster installation on Google Cloud Platform](#)

[Importing OpenShift clusters into Astra Control Center](#)

## Deploy and configure the Red Hat OpenShift Container platform on Azure

This section describes a high-level workflow of how to set up and manage OpenShift Clusters in Azure and deploy stateful applications on them. It shows the use of NetApp Cloud Volumes ONTAP storage with the help of Astra Trident/Astra Control Provisioner to provide persistent volumes. Details are provided about the use of Astra Control Center to perform data protection and migration activities for the stateful applications.

Here is a diagram that shows the clusters deployed on Azure and connected to the data center using a VPN.



There are several ways of deploying Red Hat OpenShift Container platform clusters in Azure. This high-level description of the setup provides documentation links for the specific method that was used. You can refer to the other methods in the relevant links provided in the [resources section](#).

The setup process can be broken down into the following steps:

## Install an OCP cluster on Azure from the CLI.

- Ensure that you have met all the prerequisites stated [here](#).
- Create a VPN, subnets and network security groups and a private DNS zone. Create VPN gateway and site-to-site VPN Connection.
- For the VPN connectivity between on-premises and Azure, a pfsense VM was created and configured. For instructions, see [here](#).
- Obtain the installation program and the pull secret and deploy the cluster following the steps provided in the documentation [here](#).
- The installation of the cluster completes and will provide a kubeconfig file and username and password to login to the console of the cluster.

A sample install-config.yaml file is given below.

```
apiVersion: v1
baseDomain: sddc.netapp.com
compute:
- architecture: amd64
  hyperthreading: Enabled
  name: worker
  platform:
    azure:
      encryptionAtHost: false
      osDisk:
        diskSizeGB: 512
        diskType: "StandardSSD_LRS"
      type: Standard_D2s_v3
      ultraSSDCapability: Disabled
      #zones:
      #- "1"
      #- "2"
      #- "3"
  replicas: 3
controlPlane:
  architecture: amd64
  hyperthreading: Enabled
  name: master
  platform:
    azure:
      encryptionAtHost: false
      osDisk:
        diskSizeGB: 1024
        diskType: Premium_LRS
      type: Standard_D8s_v3
      ultraSSDCapability: Disabled
  replicas: 3
```

```

metadata:
  creationTimestamp: null
  name: azure-cluster
networking:
  clusterNetwork:
  - cidr: 10.128.0.0/14
    hostPrefix: 23
  machineNetwork:
  - cidr: 10.0.0.0/16
  networkType: OVNKubernetes
  serviceNetwork:
  - 172.30.0.0/16
platform:
  azure:
    baseDomainResourceGroupName: ocp-base-domain-rg
    cloudName: AzurePublicCloud
    computeSubnet: ocp-subnet2
    controlPlaneSubnet: ocp-subnet1
    defaultMachinePlatform:
      osDisk:
        diskSizeGB: 1024
        diskType: "StandardSSD_LRS"
        ultraSSDCapability: Disabled
    networkResourceGroupName: ocp-nc-us-rg
    #outboundType: UserDefinedRouting
    region: northcentralus
    resourceGroupName: ocp-cluster-ncusrg
    virtualNetwork: ocp_vnet_ncus
publish: Internal
pullSecret:

```

### Deploy Cloud Volumes ONTAP in Azure using BlueXP.

- Install a connector in in Azure. Refer to instructions [here](#).
- Deploy a CVO instance in Azure using the connector. Refer to instructions [link:https://docs.netapp.com/us-en/bluexp-cloud-volumes-ontap/task-getting-started-azure.html](https://docs.netapp.com/us-en/bluexp-cloud-volumes-ontap/task-getting-started-azure.html) [here.]

### Install Astra Control Provisioner in the OCP Cluster in Azure

- For this project, Astra Control Provisioner (ACP) was installed on all the clusters (on-prem cluster, on-prem cluster where Astra Control Center is deployed and the cluster in Azure). Learn more about the Astra Control Provisioner [here](#).
- Create backend and a storage classes. Refer to instructions [here](#).

## Add the OCP cluster on Azure to the Astra Control Center.

- Create a separate KubeConfig file with a cluster role that contains the minimum permissions necessary for a cluster to be managed by Astra Control. The instructions can be found [here](#).
- Add the cluster to Astra Control Center following the instructions [here](#)

## Using CSI Topology feature of Trident for multi-zone architectures

Cloud providers, today, enable Kubernetes/OpenShift cluster administrators to spawn nodes of the clusters that are zone based. Nodes can be located in different availability zones within a region, or across various regions. To facilitate the provisioning of volumes for workloads in a multi-zone architecture, Astra Trident uses CSI Topology. Using the CSI Topology feature, access to volumes can be limited to a subset of nodes, based on regions and availability zones. Refer [here](#) for additional details.



Kubernetes supports two volume binding modes:

- When **VolumeBindingMode is set to Immediate** (default), Astra Trident creates the volume without any topology awareness. Persistent Volumes are created without having any dependency on the requesting pod's scheduling requirements.
- When **VolumeBindingMode set to WaitForFirstConsumer**, the creation and binding of a Persistent Volume for a PVC is delayed until a pod that uses the PVC is scheduled and created. This way, volumes are created to meet the scheduling constraints that are enforced by topology requirements.

Astra Trident storage backends can be designed to selectively provision volumes based on availability zones (Topology-aware backend). For StorageClasses that make use of such a backend, a volume would only be created if requested by an application that is scheduled in a supported region/zone. (Topology-aware StorageClass)  
Refer [here](#) for additional details.

## Demonstration Video

[Using Astra Control for Failover and Failback of applications](#)

## Data protection using Astra Control Center

This page shows the data protection options for Red Hat OpenShift Container based applications running on VMware vSphere or in the cloud using Astra Control Center (ACC).

As users take their journey of modernizing their applications with Red Hat OpenShift, a data protection strategy should be in place to protect them from accidental deletion or any other human errors. Often a protection strategy is also required for regulatory or compliance purposes to protect their data from a disaster.

The requirements of data protection varies from reverting back to a point in time copy to automatically failing over to a different fault domain without any human intervention. Many customers pick ONTAP as their preferred storage platform for their Kubernetes applications because of its rich features like multitenancy, multi-protocol, high performance and capacity offerings, replication and caching for multi-site locations, security and flexibility.

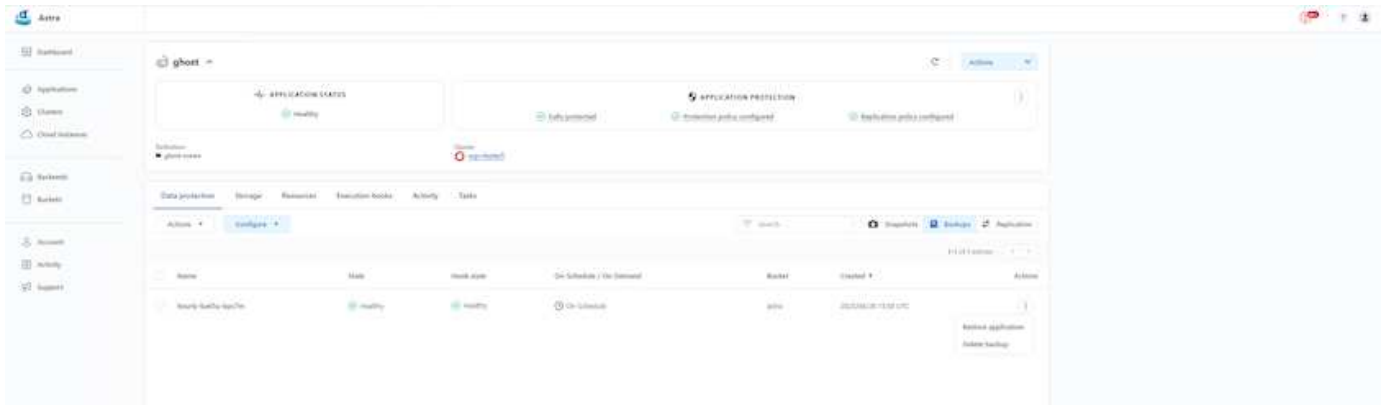
Customers may have a cloud environment setup as their data center extension, so that they can leverage the benefits of the cloud as well as be well positioned to move their workloads at a future time. For such customers, backing up of their OpenShift applications and their data to the cloud environment becomes an

inevitable choice. They can then restore the applications and the associated data either to an OpenShift cluster in the cloud or in their data center.

## Backup and Restore with ACC

Application owners can review and update the applications discovered by ACC. ACC can take Snapshot copies using CSI and perform backup using the point in time Snapshot copy. Backup destination can be an object store in the cloud environment. Protection policy can be configured for scheduled backups and the number of backup versions to keep. The minimum RPO is one hour.

### Restoring an application from a backup using ACC



## Application specific execution hooks

Even though storage array level data protection features are available, often additional steps are needed to make backups and restores application consistent. The app-specific additional steps could be:

- before or after a Snapshot copy is created.
- before or after a backup is created.
- after restoring from a Snapshot copy or backup.

Astra Control can execute these app-specific steps coded as custom scripts called execution hooks.

NetApp's [open source project Verda](#) provides execution hooks for popular cloud-native applications to make protecting applications straightforward, robust, and easy to orchestrate. Feel free to contribute to that project if you have enough information for an application that is not in the repository.

### Sample execution hook for pre-Snapshot of a redis application.



**Edit execution hook**
✕

---

**HOOK DETAILS** ?

Operation  
 Pre-snapshot

Hook arguments (optional)  
 1 pre ✕ ?  
 Enter hook arguments

Hook name  
 redis-pre-snapshot

**EXECUTION HOOKS**

Execution hooks allow Astra Control to execute your own custom scripts before or after a snapshot.

Read more in [Manage application execution hooks](#)

---

**CONTAINER IMAGES** ?

Apply to all container images

Use a regular expression to target container images for the hook.

Container image names to match:  
 redis

---

**SCRIPT** ?

+ Add
Search

Name
<input type="radio"/> mariadb_mysql.sh
<input type="radio"/> postgresql.sh
<input checked="" type="radio"/> redis_hook.sh

Cancel

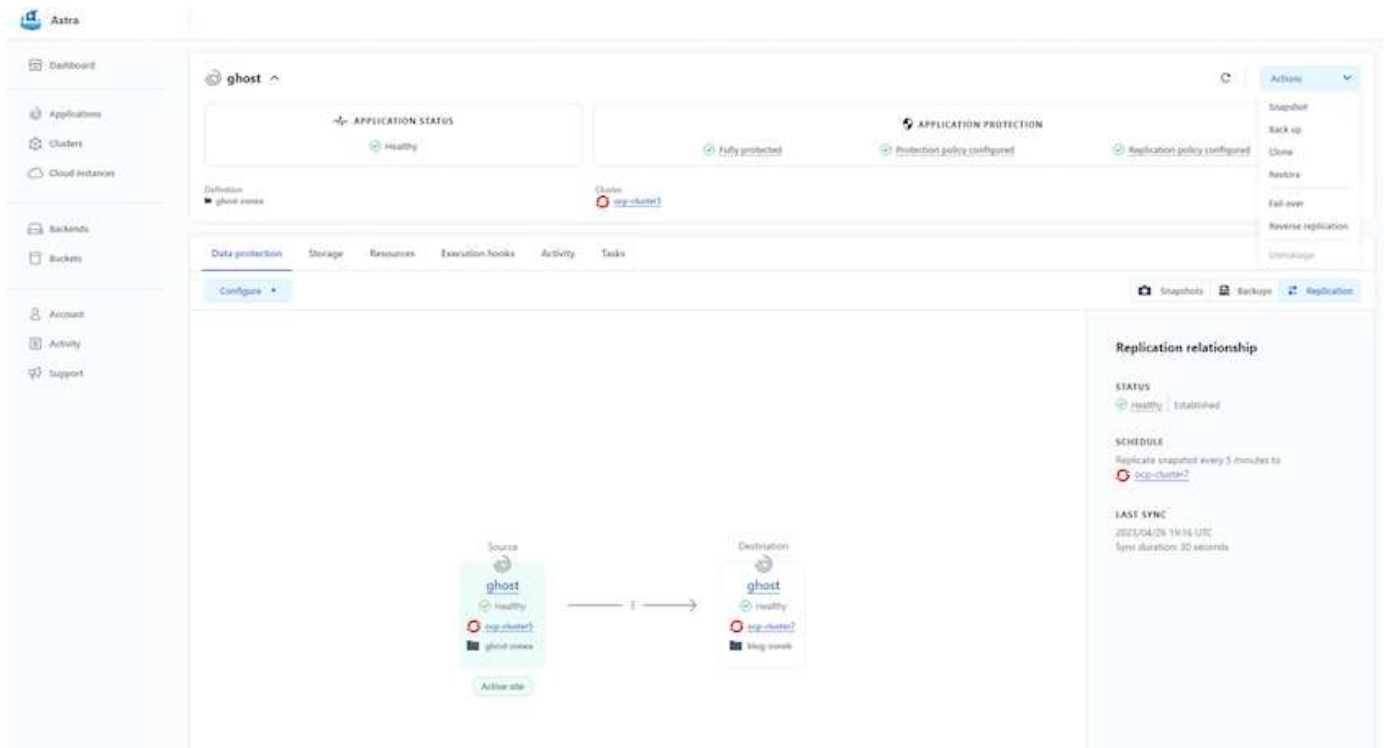
Save ✓

## Replication with ACC

For regional protection or for a low RPO and RTO solution, an application can be replicated to another Kubernetes instance running at a different site, preferably in another region. ACC utilizes ONTAP async SnapMirror with RPO as low as 5 minutes.

Refer [here](#) for SnapMirror setup instructions.

## SnapMirror with ACC



san-economy and nas-economy storage drivers do not support replication feature. Refer [here](#) for additional details.

#### Demo video:

[Demonstration video of disaster recovery with Astra Control Center](#)

[Data protection with Astra Control Center](#)

Details on Astra Control Center Data Protection features are available [here](#)

#### Disaster recovery (Failover and Failback using replication) with ACC

[Using Astra Control for Failover and Failback of applications](#)

### Data migration using Astra Control Center

This page shows the data migration options for container workloads on Red Hat OpenShift clusters with Astra Control Center (ACC). Specifically, customers can use ACC to

- move some selected workloads or all workloads from their on-premises data centers to the cloud
- clone their apps to the cloud either for testing purposes or move from the data center to the cloud

#### Data Migration

To migrate application from one environment to another, you can use one of the following features of ACC:

- replication
- backup and restore
- clone

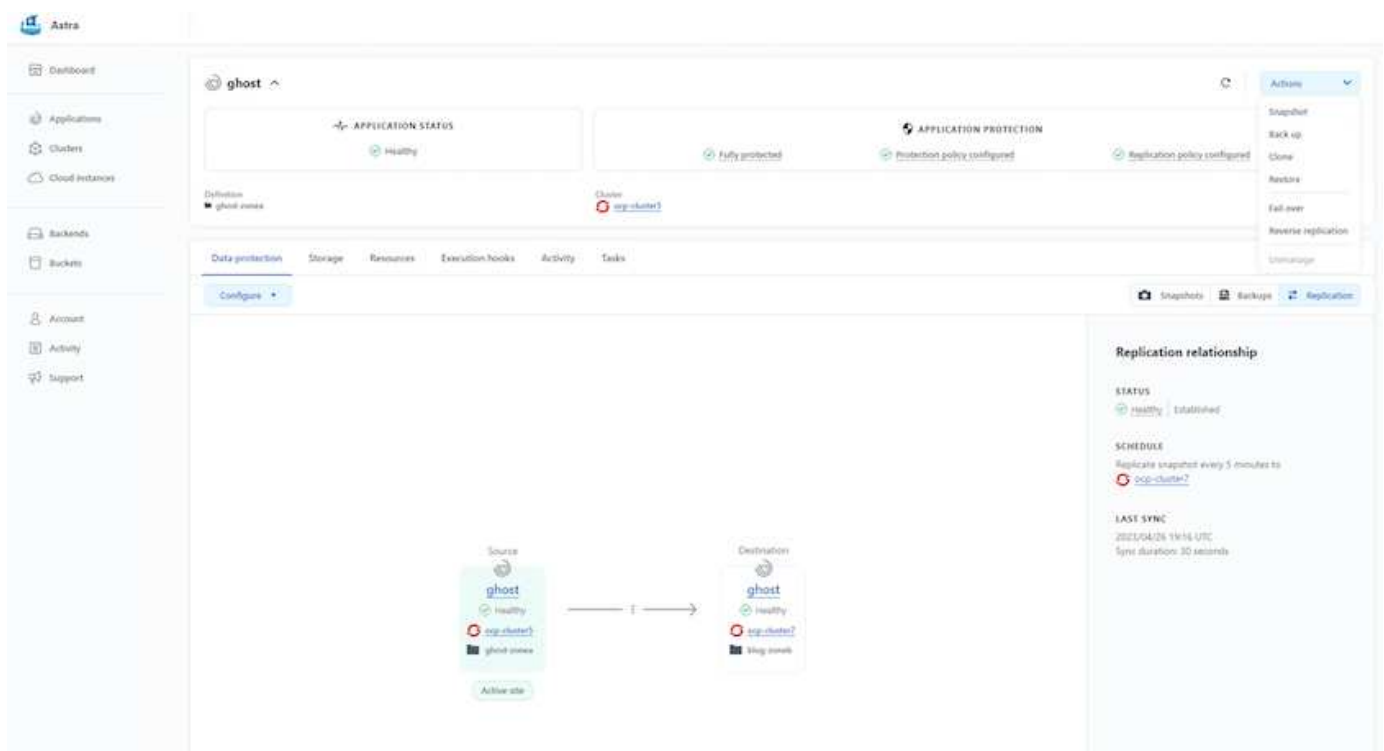
Refer to the [data protection section](#) for the **replication and backup and restore** options.

Refer [here](#) for additional details about **cloning**.



Astra Replication feature is only supported with Trident Container Storage Interface (CSI). However, replication is not supported by nas-economy & san-economy drivers.

### Performing data replication using ACC



## NetApp Hybrid Multicloud solutions for Red Hat OpenShift Container workloads

NetApp is seeing a significant increase in customers modernizing their legacy enterprise applications and building new applications using containers and orchestration platforms built around Kubernetes. Red Hat OpenShift Container Platform is one example that we see adopted by many of our customers.

### Overview

As more and more customers begin adopting containers within their enterprises, NetApp is perfectly positioned to help serve the persistent storage needs of their stateful applications and classic data management needs such as data protection, data security, and data migration. However, these needs are met using different strategies, tools, and methods.

**NetApp ONTAP** based storage options listed below, deliver security, data protection, reliability, and flexibility for containers and Kubernetes deployments.

- Self-managed storage in on-premises:
  - NetApp Fabric Attached Storage (FAS), NetApp All Flash FAS Arrays (AFF), NetApp All SAN Array (ASA) and ONTAP Select
- Provider-managed storage in on-premises:
  - NetApp Keystone provides Storage as a Service (STaaS)
- Self-managed storage in the cloud:
  - NetApp Cloud Volumes ONTAP(CVO) provide self managed storage in the hyperscalers
- Provider-managed storage in the cloud:
  - Cloud Volumes Service for Google Cloud (CVS), Azure NetApp Files (ANF), Amazon FSx for NetApp ONTAP offer fully managed storage in the hyperscalers

## ONTAP feature highlights



<p style="text-align: center;"><b>Storage Administration</b></p> <ul style="list-style-type: none"> <li>• Multi-tenancy</li> <li>• FlexVol &amp; FlexGroup</li> <li>• LUN</li> <li>• Quotas</li> <li>• ONTAP CLI &amp; API</li> <li>• System Manager &amp; BlueXP</li> </ul>	<p style="text-align: center;"><b>Performance &amp; Scalability</b></p> <ul style="list-style-type: none"> <li>• FlexCache</li> <li>• FlexClone</li> <li>• nconnect, session trunking, multipathing</li> <li>• Scale-out clusters</li> </ul>
<p style="text-align: center;"><b>Availability &amp; Resilience</b></p> <ul style="list-style-type: none"> <li>• Multi-AZ HA deployment (MetroCluster)</li> <li>• SnapShot &amp; SnapRestore</li> <li>• SnapMirror</li> <li>• SnapMirror Business Continuity</li> <li>• SnapMirror Cloud</li> </ul>	<p style="text-align: center;"><b>Access Protocols</b></p> <ul style="list-style-type: none"> <li>• NFS –v3, v4, v4.1, v4.2</li> <li>• SMB – v2, v3</li> <li>• iSCSI</li> <li>• Multi-protocol access</li> </ul>
<p style="text-align: center;"><b>Storage Efficiency</b></p> <ul style="list-style-type: none"> <li>• Deduplication &amp; Compression</li> <li>• Compaction</li> <li>• Thin provisioning</li> <li>• Data Tiering (Fabric Pool)</li> </ul>	<p style="text-align: center;"><b>Security &amp; Compliance</b></p> <ul style="list-style-type: none"> <li>• Fpolicy &amp; Vscan</li> <li>• Active Directory integration</li> <li>• LDAP &amp; Kerberos</li> <li>• Certificate based authentication</li> </ul>

**NetApp BlueXP** enables you to manage all of your storage and data assets from a single control plane/interface.

You can use BlueXP to create and administer cloud storage (for example, Cloud Volumes ONTAP and Azure NetApp Files), to move, protect, and analyze data, and to control many on-prem and edge storage devices.

**NetApp Astra Trident** is a CSI Compliant Storage Orchestrator that enable quick and easy consumption of persistent storage backed by a variety of the above-mentioned NetApp storage options. It is an open-source software maintained and supported by NetApp.



## Astra Trident CSI feature highlights

<p style="text-align: center;"><b>CSI specific</b></p> <ul style="list-style-type: none"> <li>• CSI NetApp® Snapshot™ copies and volume creation from CSI Snapshot copies</li> <li>• CSI topology</li> <li>• Volume expansion</li> </ul>	<p style="text-align: center;"><b>Security</b></p> <ul style="list-style-type: none"> <li>• Dynamic-export policy management</li> <li>• iSCSI initiator-groups dynamic management</li> <li>• iSCSI bidirectional CHAP</li> </ul>
<p style="text-align: center;"><b>Control</b></p> <ul style="list-style-type: none"> <li>• Storage and performance consumption</li> <li>• Monitoring</li> <li>• Volume Import</li> <li>• Cross Namespace Volume Access</li> </ul>	<p style="text-align: center;"><b>Installation methods</b></p> <ul style="list-style-type: none"> <li>• Binary</li> <li>• Helm chart</li> <li>• Operator</li> <li>• GitOps</li> </ul>
<p style="text-align: center;"><b>Choose your access mode</b></p> <ul style="list-style-type: none"> <li>• RWO (<i>ReadWriteOnce</i>, i.e 1↔1)</li> <li>• RWX (<i>ReadWriteMany</i>, i.e 1↔n)</li> <li>• ROX (<i>ReadOnlyMany</i>)</li> <li>• RWOP (<i>ReadWriteOnce</i> POD)</li> </ul>	<p style="text-align: center;"><b>Choose your protocol</b></p> <ul style="list-style-type: none"> <li>• NFS</li> <li>• SMB</li> <li>• iSCSI</li> </ul>

Business critical container workloads need more than just persistent volumes. Their data management requirements require protection and migration of the application kubernetes objects as well.



Application data includes kubernetes objects in addition to the user data: Some examples are as follows:

- kubernetes objects such as pods specs, PVCs, deployments, services
- custom config objects such as config maps and secrets
- persistent data such as Snapshot copies, backups, clones
- custom resources such as CRs and CRDs

**NetApp Astra Control**, available as both fully-managed and self-managed software, provides orchestration for robust application data management. Refer to the [Astra documentation](#) for additional details on the Astra family of products.

This reference documentation provides validation of migration and protection of container-based applications, deployed on RedHat OpenShift container platform, using NetApp Astra Control Center. In addition, the solution provides high-level details for the deployment and the use of Red Hat Advanced Cluster Management (ACM) for managing the container platforms. The document also highlights the details for the integration of NetApp storage with Red Hat OpenShift container platforms using Astra Trident CSI provisioner. Astra Control Center is deployed on the hub cluster and is used to manage the container applications and their persistent storage lifecycle. Finally, it provides a solution for replication and failover and fail-back for container workloads on managed Red Hat OpenShift clusters in AWS (ROSA) using Amazon FSx for NetApp ONTAP (FSxN) as persistent storage.

### NetApp Solution with Managed Red Hat OpenShift Container platform workloads on AWS

Customers may be "born in the cloud" or may be at a point in their modernization journey when they are ready to move some select workloads or all workloads from their data centers to the cloud. They may choose to use provider-managed OpenShift containers and provider-managed NetApp storage in the cloud for running their workloads. They should plan and deploy the Managed Red Hat OpenShift container clusters (ROSA) in

the cloud for a successful production-ready environment for their container workloads. When they are in AWS cloud, they could also deploy FSx for NetApp ONTAP for the storage needs.

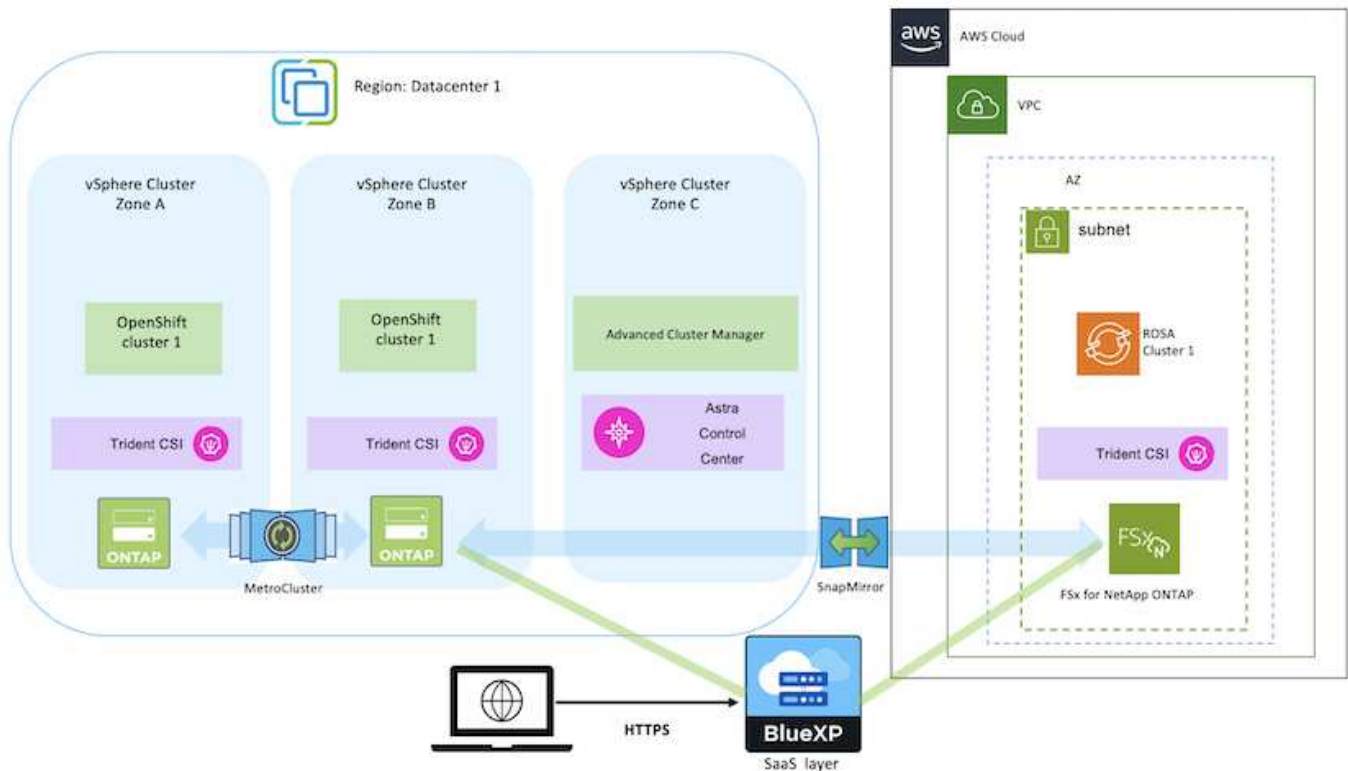
FSx for NetApp ONTAP delivers data protection, reliability, and flexibility for container deployments in AWS. Astra Trident serves as the dynamic storage provisioner to consume the persistent FSxN storage for customers' stateful applications.

As ROSA can be deployed in HA mode with control plane nodes spread across multiple availability zones, FSx ONTAP can also be provisioned with Multi-AZ option which provides high availability and protect against AZ failures.



There are no data transfer charges when accessing an Amazon FSx file system from the file system's preferred Availability Zone (AZ). For more info on pricing, refer [here](#).

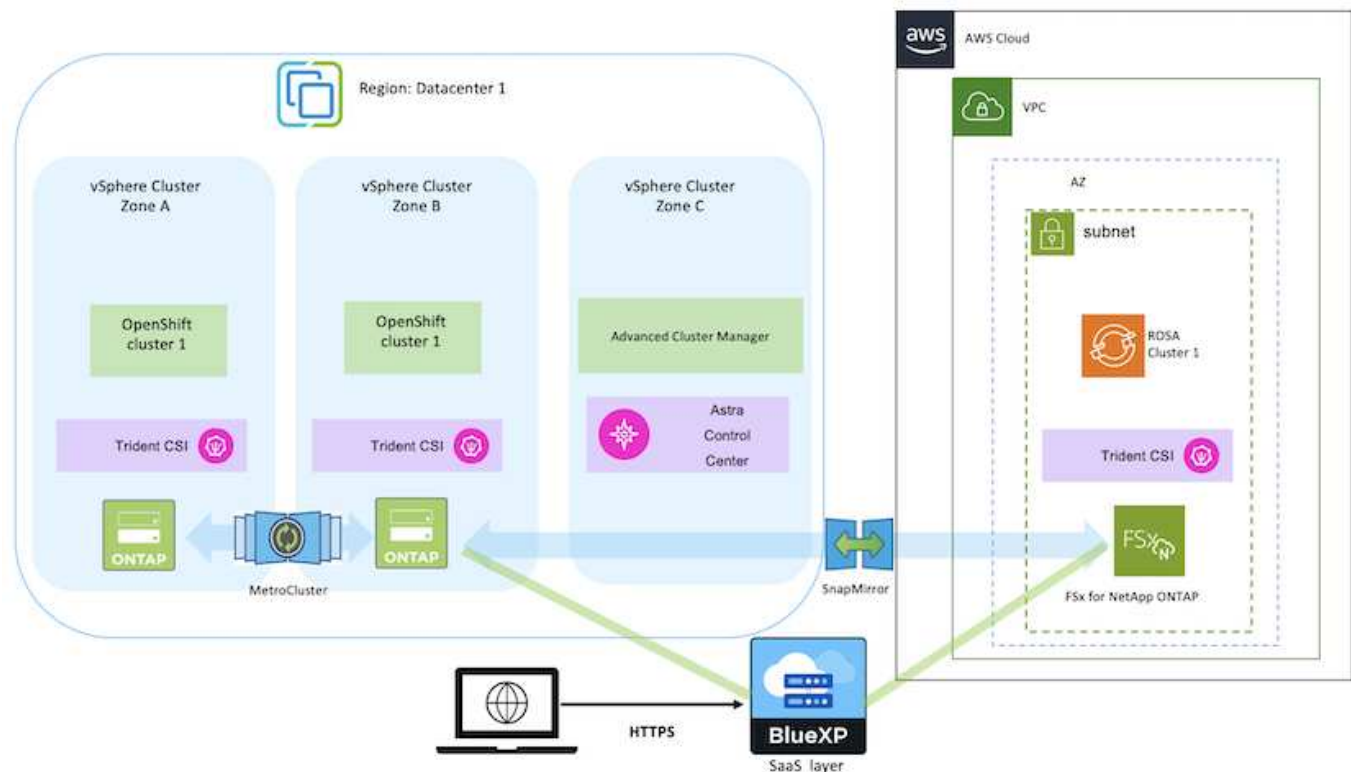
### Data protection and migration solution for OpenShift Container workloads



### Deploy and configure the Managed Red Hat OpenShift Container platform on AWS

This section describes a high-level workflow of setting up the Managed Red Hat OpenShift clusters on AWS(ROSA). It shows the use of Managed FSx for NetApp ONTAP (FSxN) as the storage backend by Astra Trident to provide persistent volumes. Details are provided about the deployment of FSxN on AWS using BlueXP. Also, details are provided about the use of BlueXP and OpenShift GitOps (Argo CD) to perform data protection and migration activities for the stateful applications on ROSA clusters.

Here is a diagram that depicts the ROSA clusters deployed on AWS and using FSxN as the backend storage.



This solution was verified by using two ROSA clusters in two VPCs in AWS. Each ROSA cluster was integrated with FSxN using Astra Trident. There are several ways of deploying ROSA clusters and FSxN in AWS. This high-level description of the setup provides documentation links for the specific method that was used. You can refer to the other methods in the relevant links provided in the [resources section](#).

The setup process can be broken down into the following steps:

### Install ROSA clusters

- Create two VPCs and set up VPC peering connectivity between the VPCs.
- Refer [here](#) for instructions to install ROSA clusters.

### Install FSxN

- Install FSxN on the VPCs from BlueXP.  
Refer [here](#) for BlueXP account creation and to get started.  
Refer [here](#) for installing FSxN.  
Refer [here](#) for creating a connector in AWS to manage the FSxN.
- Deploy FSxN using AWS.  
Refer [here](#) for deployment using AWS console.

## Install Trident on ROSA clusters (using Helm chart)

- Use Helm chart to install Trident on ROSA clusters.  
url for the Helm chart: <https://netapp.github.io/trident-helm-chart>

### Integration of FSxN with Astra Trident for ROSA clusters



OpenShift GitOps can be utilized to deploy Astra Trident CSI to all managed clusters as they get registered to ArgoCD using ApplicationSet.

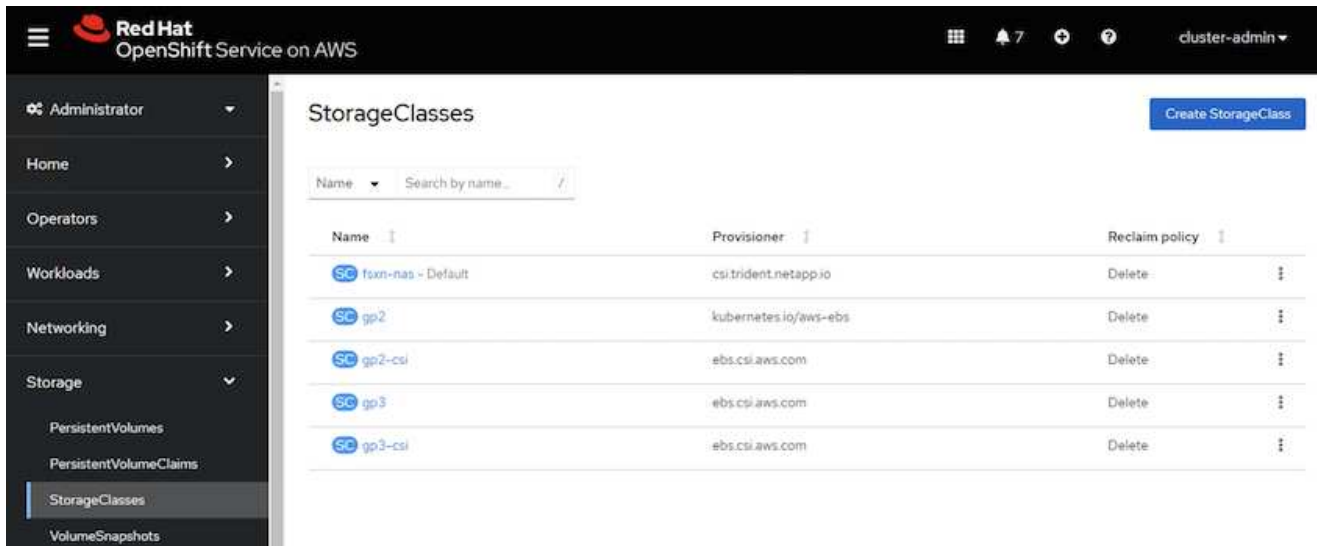
```
apiVersion: argoproj.io/v1alpha1
kind: ApplicationSet
metadata:
  name: trident-operator
spec:
  generators:
  - clusters: {}
    # selector:
    #   matchLabels:
    #     tridentversion: '23.04.0'
  template:
    metadata:
      name: '{{nameNormalized}}-trident'
    spec:
      destination:
        namespace: trident
        server: '{{server}}'
      source:
        repoURL: 'https://netapp.github.io/trident-helm-chart'
        targetRevision: 23.04.0
        chart: trident-operator
        project: default
        syncPolicy:
          syncOptions:
            - CreateNamespace=true
```





## Create backend and storage classes using Trident (for FSxN)

- Refer [here](#) for details about creating backend and storage class.
- Make the storage class created for FsxN with Trident CSI as default from OpenShift Console. See screenshot below:



## Deploy an application using OpenShift GitOps (Argo CD)

- Install OpenShift GitOps operator on the cluster. Refer to instructions [here](#).
- Set up a new Argo CD instance for the cluster. Refer to instructions [here](#).

Open the console of Argo CD and deploy an app.

As an example, you can deploy a Jenkins App using Argo CD with a Helm Chart.

When creating the application, the following details were provided:

Project: default

cluster: <https://kubernetes.default.svc>

Namespace: Jenkins

The url for the Helm Chart: <https://charts.bitnami.com/bitnami>

Helm Parameters:

global.storageClass: fsxn-nas

## Data protection

This page shows the data protection options for Managed Red Hat OpenShift on AWS (ROSA) clusters using Astra Control Service. Astra Control Service (ACS) provides an easy-to-use graphical user-interface with which you can add clusters, define applications running on them, and perform application aware data management activities. ACS functions can also be accessed using an API that allows for automation of workflows.

Powering Astra Control (ACS or ACC) is NetApp Astra Trident. Astra Trident integrates several types of Kubernetes clusters such as Red Hat OpenShift, EKS, AKS, SUSE Rancher, Anthos etc., with various flavors of NetApp ONTAP storage such as FAS/AFF, ONTAP Select, CVO, Google Cloud Volumes Service, Azure

NetApp Files and Amazon FSx for NetApp ONTAP.

This section provides details for the following data protection options using ACS:

- A video showing Backup and Restore of a ROSA application running in one region and restoring to another region.
- A video showing Snapshot and Restore of a ROSA application.
- Step-by-step details of installing a ROSA cluster, Amazon FSx for NetApp ONTAP, using NetApp Astra Trident to integrate with storage backend, installing a postgresql application on ROSA cluster, using ACS to create a snapshot of the application and restoring the application from it.
- A blog showing step-by-step details of creating and restoring from a snapshot for a mysql application on a ROSA cluster with FSx for ONTAP using ACS.

### **Backup/Restore from Backup**

The following video shows the backup of a ROSA application running in one region and restoring to another region.

[FSx NetApp ONTAP for Red Hat OpenShift Service on AWS](#)

### **Snapshot/Restore from snapshot**

The following video shows taking a snapshot of a ROSA application and restoring from the snapshot after.

[Snapshot/Restore for Applications on Red Hat OpenShift Service on AWS \(ROSA\)clusters with Amazon FSx for NetApp ONTAP storage](#)

### **Blog**

- [Using Astra Control Service for data management of apps on ROSA clusters with Amazon FSx storage](#)

### **Step-by-Step Details to create snapshot and restore from it**

#### **Prerequisite setup**

- [AWS account](#)
- [Red Hat OpenShift account](#)
- IAM user with [appropriate permissions](#) to create and access ROSA cluster
- [AWS CLI](#)
- [ROSA CLI](#)
- [OpenShift CLI\(oc\)](#)
- VPC with subnets and appropriate gateways and routes
- [ROSA Cluster installed](#) into the VPC
- [Amazon FSx for NetApp ONTAP](#) created in the same VPC
- Access to the ROSA cluster from [OpenShift Hybrid Cloud Console](#)

#### **Next Steps**

1. Create an admin user and login to the cluster.

2. Create a kubeconfig file for the cluster.
3. Install Astra Trident on the cluster.
4. Create a backend, storage class and snapshot class configuration using the Trident CSI provisioner.
5. Deploy a postgresql application on the cluster.
6. Create a database and add a record.
7. Add the cluster into ACS.
8. Define the application in ACS.
9. Create a snapshot using ACS.
10. Delete the database in the postgresql application.
11. Restore from a snapshot using ACS.
12. Verify your app has been restored from the snapshot.

### 1. Create an admin user and login to the cluster

Access the ROSA cluster by creating an admin user with the following command : (You need to create an admin user only if you did not create one at the time of installation)

```
rosa create admin --cluster=<cluster-name>
```

The command will provide an output that will look like the following. Login to the cluster using the `oc login` command provided in the output.

```
W: It is recommended to add an identity provider to login to this cluster.
See 'rosa create idp --help' for more information.
I: Admin account has been added to cluster 'my-rosa-cluster'. It may take up
to a minute for the account to become active.
I: To login, run the following command:
oc login https://api.my-rosa-cluster.abcd.p1.openshiftapps.com:6443 \
--username cluster-admin \
--password FWGYL-2mkJI-00000-00000
```



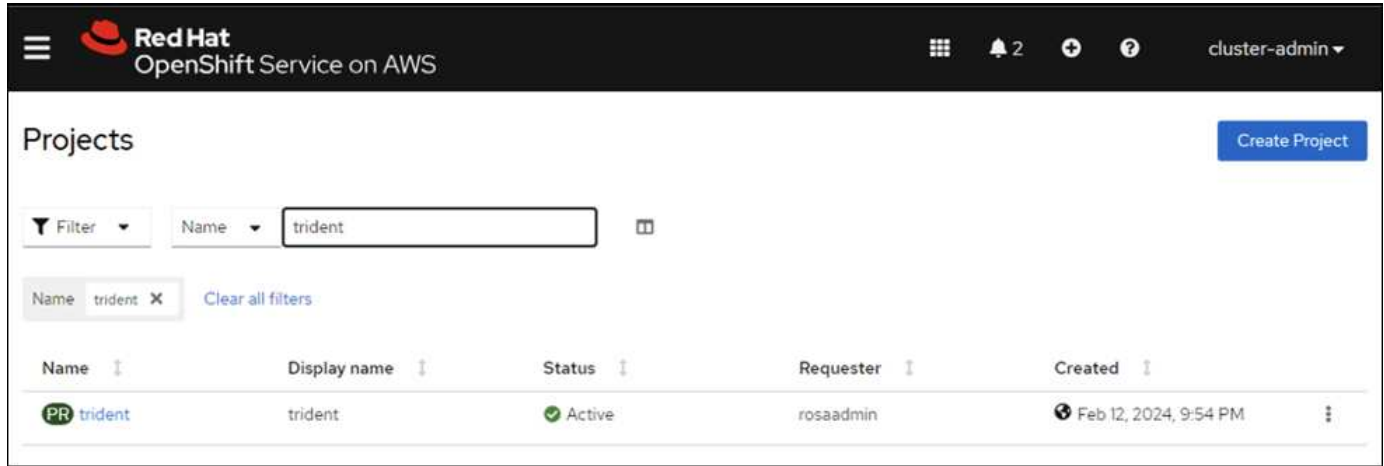
You can also login to the cluster using a token. If you already created an admin-user at the time of cluster creation, you can login to the cluster from the Red Hat OpenShift Hybrid Cloud console with the admin-user credentials. Then by clicking on the top right corner where it displays the name of the logged in user, you can obtain the `oc login` command (token login) for the command line.

### 2. Create a kubeconfig file for the cluster

Follow the procedures [here](#) to create a kubeconfig file for the ROSA cluster. This kubeconfig file will be used later when you add the cluster into ACS.

### 3. Install Astra Trident on the cluster

Install Astra Trident (latest version) on the ROSA cluster. To do this, you can follow any one of the procedures given [here](#). To install Trident using helm from the console of the cluster, first create a project called Trident.



Then from the Developer view, create a Helm chart repository. For the URL field use 'https://netapp.github.io/trident-helm-chart'. Then create a helm release for Trident operator.

## Create Helm Chart Repository

Add helm chart repository.

Configure via:  Form view  YAML view

### Scope type

- Namespaced scoped (ProjectHelmChartRepository)  
Add Helm Chart Repository in the selected namespace.
- Cluster scoped (HelmChartRepository)  
Add Helm Chart Repository at the cluster level and in all namespaces.

### Name \*

trident

A unique name for the Helm Chart repository.

### Display name

Astra Trident

A display name for the Helm Chart repository.

### Description

NetApp Astra Trident

A description for the Helm Chart repository.

Disable usage of the repo in the developer catalog.

### URL \*

https://netapp.github.io/trident-helm-chart

Project: trident ▼

Developer Catalog > Helm Charts

# Helm Charts

Browse for charts that help manage complex installations and upgrades. Cluster administrators can customize the catalog. Alternatively, developers can [try to configure their own custom Helm Chart repository](#).

All items

CI/CD

Languages

Other

**Chart Repositories**

Astra Trident (1)

OpenShift Helm Charts (87)

**Source**

Community (33)


Partner (42)

Red Hat (12)

All items

Filter by keyword...

A-Z ▼



Helm Charts

## Trident Operator

A Helm chart for deploying NetApp's Trident CSI storage provisioner using the Trident...

Verify all trident pods are running by going back to the Administrator view on the console and selecting pods in the trident project.

Project: trident

### Pods

Filter Name Search by name...

Name ↑	Status ↓	Ready ↓	Restarts ↓	Owner ↓	Memory
trident-controller-69cff44ddf-4dqnj	Running	6/6	0	trident-controller-69cff44ddf	-
trident-node-linux-4b6fm	Running	2/2	0	trident-node-linux	-
trident-node-linux-4sckw	Running	2/2	0	trident-node-linux	-
trident-node-linux-7142w	Running	2/2	0	trident-node-linux	-
trident-node-linux-dbhp4	Running	2/2	0	trident-node-linux	-
trident-node-linux-gj5km	Running	2/2	0	trident-node-linux	-
trident-node-linux-r79c8	Running	2/2	0	trident-node-linux	-
trident-node-linux-tzwdp	Running	2/2	0	trident-node-linux	-
trident-node-linux-vdvxt	Running	2/2	0	trident-node-linux	-
trident-operator-7f7fd45c68-6crbc	Running	1/1	0	trident-operator-7f7fd45c68	-

#### 4. Create a backend, storage class and snapshot class configuration using the Trident CSI provisioner

Use the yaml files shown below to create a trident backend object, storage class object and the Volumesnapshot object. Be sure to provide the credentials to your Amazon FSx for NetApp ONTAP file system you created, the management LIF and the vserver name of your file system in the configuration yaml for the backend. To get those details, go to the AWS console for Amazon FSx and select the file system, navigate to the Administration tab. Also, click on update to set the password for the `fsxadmin` user.



You can use the command line to create the objects or create them with the yaml files from the hybrid cloud console.

FSx > File systems > fs-049f9a23aac951429

## fsx-for-rosa (fs-049f9a23aac951429)

▼ Summary

File system ID fs-049f9a23aac951429	SSD storage capacity 1024 GiB	<input type="button" value="Update"/>	Availability Zones us-west-2b
Lifecycle state Available	Throughput capacity 128 MB/s	<input type="button" value="Update"/>	Creation time 2024-02-12T20:15:23-05:00
File system type ONTAP	Provisioned IOPS 3072	<input type="button" value="Update"/>	
Deployment type Single-AZ	Number of HA pairs 1		

Network & security | Monitoring & performance | **Administration** | Storage virtual machines | Volumes | Backups | Updates | Tags

### ONTAP administration

Management endpoint - DNS name management.fs-049f9a23aac951429.fsx.us-west-2.amazonaws.com	Management endpoint - IP address 10.49.9.135	ONTAP administrator username fsxadmin
Inter-cluster endpoint - DNS name intercluster.fs-049f9a23aac951429.fsx.us-west-2.amazonaws.com	Inter-cluster endpoint - IP address 10.49.9.49	ONTAP administrator password <input type="button" value="Update"/>
	10.49.9.251	

## Trident Backend Configuration

```

apiVersion: v1
kind: Secret
metadata:
  name: backend-tbc-ontap-nas-secret
type: Opaque
stringData:
  username: fsxadmin
  password: <password>
---
apiVersion: trident.netapp.io/v1
kind: TridentBackendConfig
metadata:
  name: ontap-nas
spec:
  version: 1
  storageDriverName: ontap-nas
  managementLIF: <management lif>
  backendName: ontap-nas
  svm: fsx
  credentials:
    name: backend-tbc-ontap-nas-secret

```

## Storage Class



```

apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: ontap-nas
provisioner: csi.trident.netapp.io
parameters:
  backendType: "ontap-nas"
  media: "ssd"
  provisioningType: "thin"
  snapshots: "true"
allowVolumeExpansion: true

```

## snapshot class

```

apiVersion: snapshot.storage.k8s.io/v1
kind: VolumeSnapshotClass
metadata:
  name: trident-snapshotclass
driver: csi.trident.netapp.io
deletionPolicy: Delete

```

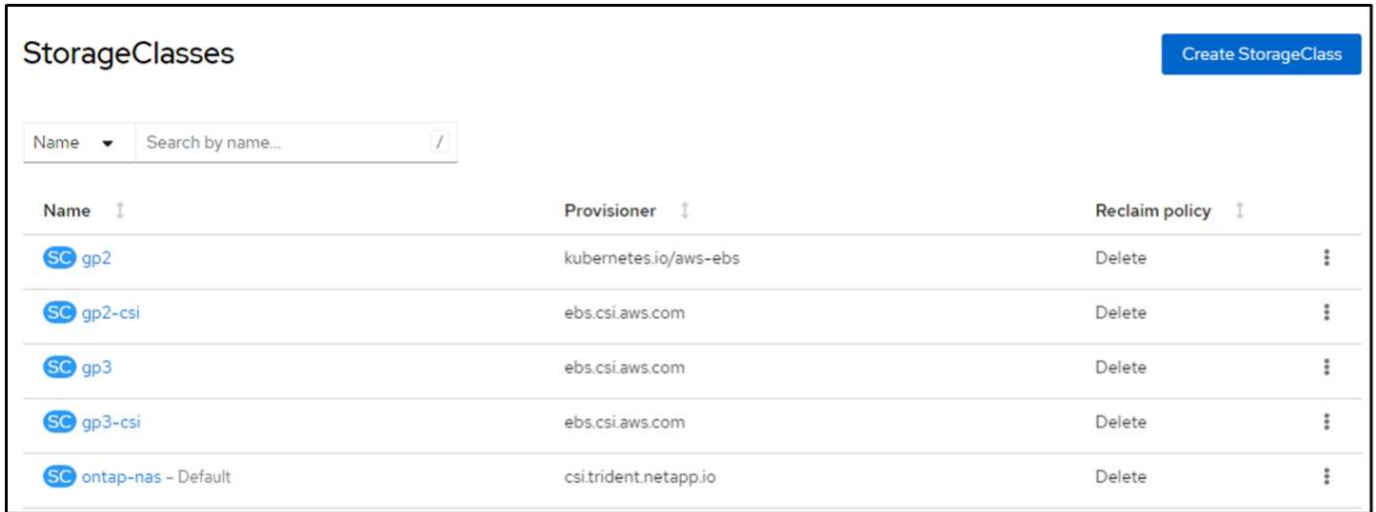
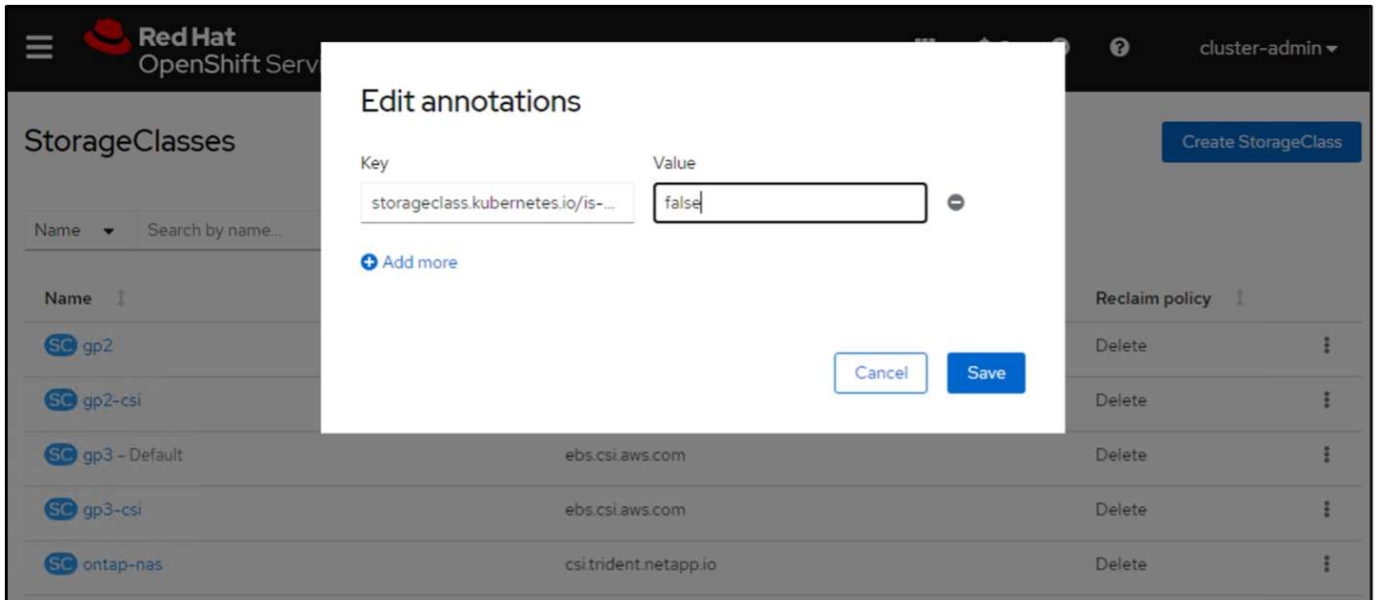
Verify that the backend, storage class and the trident-snapshotclass objects are created by issuing the commands shown below.

```

[ec2-user@ip-10-49-11-132 storage]$ kubectl get tbc -n trident
NAME          BACKEND NAME   BACKEND UUID          PHASE   STATUS
ontap-nas     ontap-nas     8a5e4583-2dac-46bb-b01e-fa7c3816f121  Bound   Success
[ec2-user@ip-10-49-11-132 storage]$ kubectl get sc
NAME          PROVISIONER          RECLAIMPOLICY   VOLUMEBINDINGMODE   ALLOWVOLUMEEXPANSION   AGE
gp2           kubernetes.io/aws-ebs  Delete          WaitForFirstConsumer true                   3h23m
gp2-csi       ebs.csi.aws.com      Delete          WaitForFirstConsumer true                   3h19m
gp3 (default) ebs.csi.aws.com      Delete          WaitForFirstConsumer true                   3h23m
gp3-csi       ebs.csi.aws.com      Delete          WaitForFirstConsumer true                   3h19m
ontap-nas     csi.trident.netapp.io Delete          Immediate            true                   141m
[ec2-user@ip-10-49-11-132 storage]$ kubectl get Volumesnapshotclass
NAME          DRIVER          DELETIONPOLICY   AGE
csi-aws-vsc   ebs.csi.aws.com Delete           3h19m
trident-snapshotclass csi.trident.netapp.io Delete           6m56s
[ec2-user@ip-10-49-11-132 storage]$

```

At this time, an important modification you need to make is to set ontap-nas as the default storage class instead of gp3 so that the postgresql app you deploy later can use the default storage class. In the Openshift console of your cluster, under Storage select StorageClasses. Edit the annotation of the current default class to be false and add the annotation storageclass.kubernetes.io/is-default-class set to true for the ontap-nas storage class.



## 5. Deploy a postgresql application on the cluster

You can deploy the application from the command line as follows:

```
helm install postgresql bitnami/postgresql -n postgresql --create-namespace
```

```
[ec2-user@ip-10-49-11-132 astra]$ helm install postgresql bitnami/postgresql -n postgresql --create-namespace
NAME: postgresql
LAST DEPLOYED: Tue Feb 13 14:46:16 2024
NAMESPACE: postgresql
STATUS: deployed
REVISION: 1
TEST SUITE: None
NOTES:
CHART NAME: postgresql
CHART VERSION: 14.0.4
APP VERSION: 16.2.0

** Please be patient while the chart is being deployed **

PostgreSQL can be accessed via port 5432 on the following DNS names from within your cluster:

    postgresql.postgresql.svc.cluster.local - Read/Write connection

To get the password for "postgres" run:

    export POSTGRES_PASSWORD=$(kubectl get secret --namespace postgresql postgresql -o jsonpath="{.data.postgres-password}" | base64 -d)

To connect to your database run the following command:

    kubectl run postgresql-client --rm --tty -i --restart='Never' --namespace postgresql --image docker.io/bitnami/postgresql:16.2.0-debian-11-r1 --env="PGPASSWORD=$POSTGRES_PASSWORD" \
    --command -- psql --host postgresql -U postgres -d postgres -p 5432

    > NOTE: If you access the container using bash, make sure that you execute "/opt/bitnami/scripts/postgresql/entrypoint.sh /bin/bash" in order to avoid
    the error "psql: local user with ID 1001} does not exist"

To connect to your database from outside the cluster execute the following commands:

    kubectl port-forward --namespace postgresql svc/postgresql 5432:5432 &
    PGPASSWORD="$POSTGRES_PASSWORD" psql --host 127.0.0.1 -U postgres -d postgres -p 5432

WARNING: The configured password will be ignored on new installation in case when previous PostgreSQL release was deleted through the helm command. In that
case, old PVC will have an old password, and setting it through helm won't take effect. Deleting persistent volumes (PVs) will solve the issue.
[ec2-user@ip-10-49-11-132 astra]$
```

If you do not see the application pods running, then there might be an error caused due to security context constraints.

```
[ec2-user@ip-10-49-11-132 astra]$ kubectl get all -n postgresql
NAME                                TYPE                CLUSTER-IP      EXTERNAL-IP      PORT(S)          AGE
service/postgresql                  ClusterIP          172.30.245.50   <none>           5432/TCP         12m
service/postgresql-hl               ClusterIP          None            <none>           5432/TCP         12m

NAME                                READY   AGE
statefulset.apps/postgresql          0/1     12m
[ec2-user@ip-10-49-11-132 astra]$ kubectl get events -n postgresql
LAST SEEN   TYPE      REASON              OBJECT                                          MESSAGE
12m         Normal   WaitForFirstConsumer  persistentvolumeclaim/data-postgresql-0      waiting for first consumer to be created before binding
12m         Normal   SuccessfulCreate     statefulset/postgresql                        create Claim data-postgresql-0 Pod postgresql-0 in StatefulSet postg
psql success
107s        Warning  FailedCreate        statefulset/postgresql                        create Pod postgresql-0 in StatefulSet postgresql failed error: pods
"postgresql-0" is forbidden: unable to validate against any security context constraint: [provider "trident-controller": Forbidden: not usable by user or
serviceaccount, provider "anyuid": Forbidden: not usable by user or serviceaccount, provider "restricted-v2": .spec.securityContext.fsGroup: Invalid value: [
[int64(1001): 1001 is not an allowed group, provider "restricted-v2": .containers[0].runAsUser: Invalid value: 1001: must be in the ranges: [1001010000, 1001
019999], provider "restricted": Forbidden: not usable by user or serviceaccount, provider "nonroot-v2": Forbidden: not usable by user or serviceaccount, pr
ovider "nonroot": Forbidden: not usable by user or serviceaccount, provider "pcap-dedicated-admins": Forbidden: not usable by user or serviceaccount, provi
der "hostmount-anyuid": Forbidden: not usable by user or serviceaccount, provider "machine-api-termination-handler": Forbidden: not usable by user or servi
ceaccount, provider "hostnetwork-v2": Forbidden: not usable by user or serviceaccount, provider "hostnetwork": Forbidden: not usable by user or serviceacco
unt, provider "hostaccess": Forbidden: not usable by user or serviceaccount, provider "splunkforwarder": Forbidden: not usable by user or serviceaccount, p
rovider "trident-node-linux": Forbidden: not usable by user or serviceaccount, provider "node-exporter": Forbidden: not usable by user or serviceaccount, p
rovider "privileged": Forbidden: not usable by user or serviceaccount]
[ec2-user@ip-10-49-11-132 astra]$
```



Fix the error by editing the runAsUser and fsGroup fields in statefulset.apps/postgresql object with the uid that is in the output of the oc get project command as shown below.

```
[ec2-user@ip-10-49-11-132 astra]$ oc get project postgresql -o yaml | grep uid-range
openshift.io/sa.scc.uid-range: 1001010000/10000
[ec2-user@ip-10-49-11-132 astra]$ oc edit -n postgresql statefulset.apps/postgresql
statefulset.apps/postgresql edited
[ec2-user@ip-10-49-11-132 astra]$
```

postgresql app should be running and using persistent volumes backed by Amazon FSx for NetApp ONTAP storage.

```
[ec2-user@ip-10-49-11-132 astra]$ oc get pods -n postgresql
NAME          READY  STATUS   RESTARTS  AGE
postgresql-0  1/1   Running  0         2m46s
[ec2-user@ip-10-49-11-132 astra]$
```

```
[ec2-user@ip-10-49-11-132 storage]$ kubectl get pvc -n postgresql
NAME          STATUS  VOLUME                                     CAPACITY  ACCESS MODES  STORAGECLASS  AGE
data-postgresql-0  Bound  pvc-dd09524a-de75-4825-9424-03a9b91195ca  8Gi       RWO           ontap-nas    4m2s
[ec2-user@ip-10-49-11-132 storage]$
```

## 6. Create a database and add a record

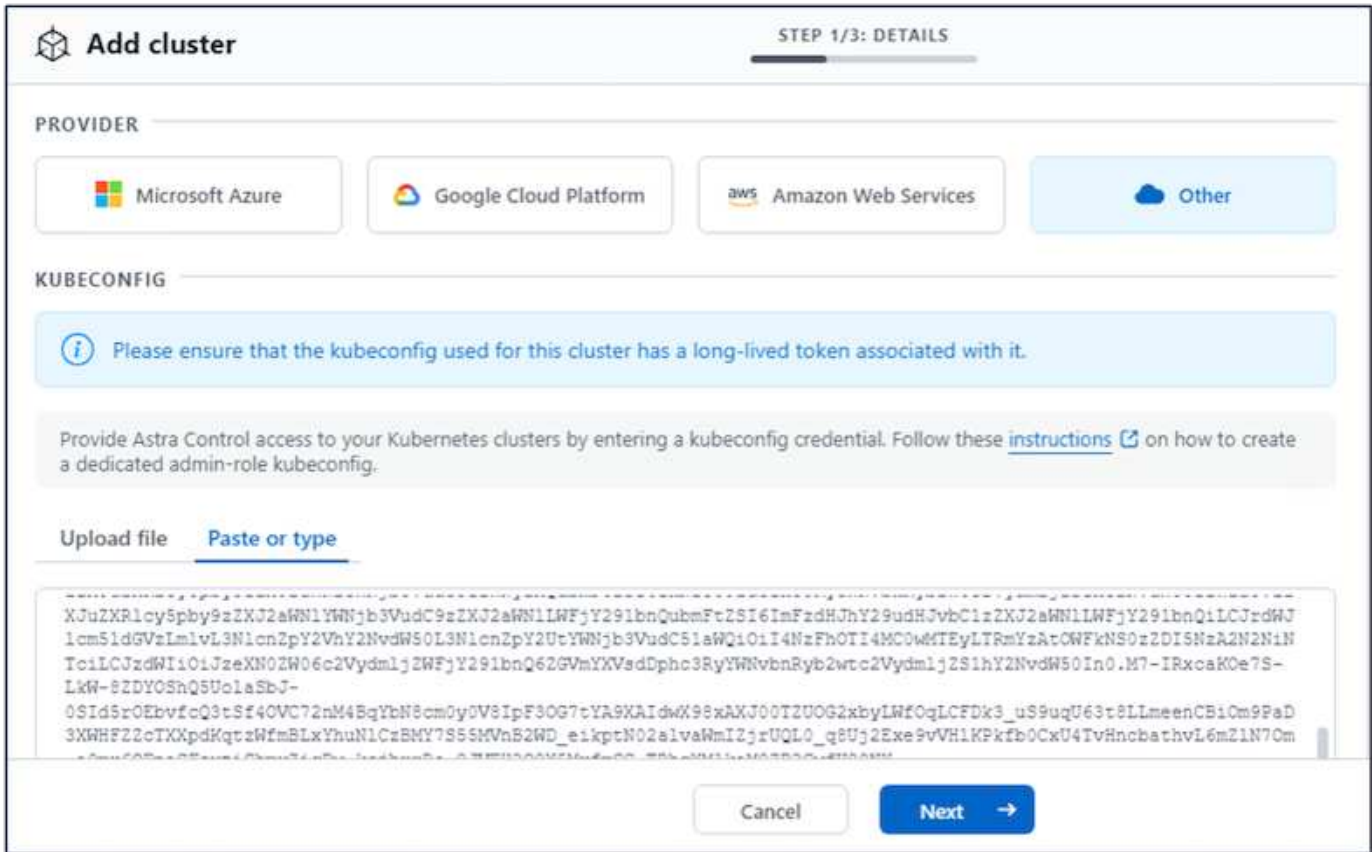
```
[ec2-user@ip-10-49-11-132 astra]$ export POSTGRES_PASSWORD=$(kubectl get secret --namespace postgresql postgresql -o jsonpath='{.data.postgres-password}' | base64 -d)
[ec2-user@ip-10-49-11-132 astra]$ kubectl run postgresql-client --rm --tty -i --restart='Never' --namespace postgresql --image docker.io/bitnami/postgresql:16.2.0-debian-11-r1 --env="PGPASSWORD=$POSTGRES_PASSWORD" \
> --command -- psql --host postgresql -U postgres -d postgres -p 5432
Warning: would violate PodSecurity "restricted:vi1.24": allowPrivilegeEscalation != false (container "postgresql-client" must set securityContext.allowPrivilegeEscalation=false), unrestricted capabilities (container "postgresql-client" must set securityContext.capabilities.drop=["ALL"]), runAsNonRoot != true (pod or container "postgresql-client" must set securityContext.runAsNonRoot=true), seccompProfile (pod or container "postgresql-client" must set securityContext.seccompProfile.type to "RuntimeDefault" or "Localhost")
If you don't see a command prompt, try pressing enter.

postgres=# CREATE DATABASE erp;
CREATE DATABASE
postgres=# \c erp
You are now connected to database "erp" as user "postgres".
erp=# CREATE TABLE PERSONS(ID INT PRIMARY KEY NOT NULL, FIRSTNAME TEXT NOT NULL, LASTNAME TEXT NOT NULL);
CREATE TABLE
erp=# INSERT INTO PERSONS VALUES(1,'John','Doe');
INSERT 0 1
erp=# \dt
          List of relations
 Schema | Name  | Type  | Owner
-----|-----|-----|-----
 public | persons | table | postgres
(1 row)

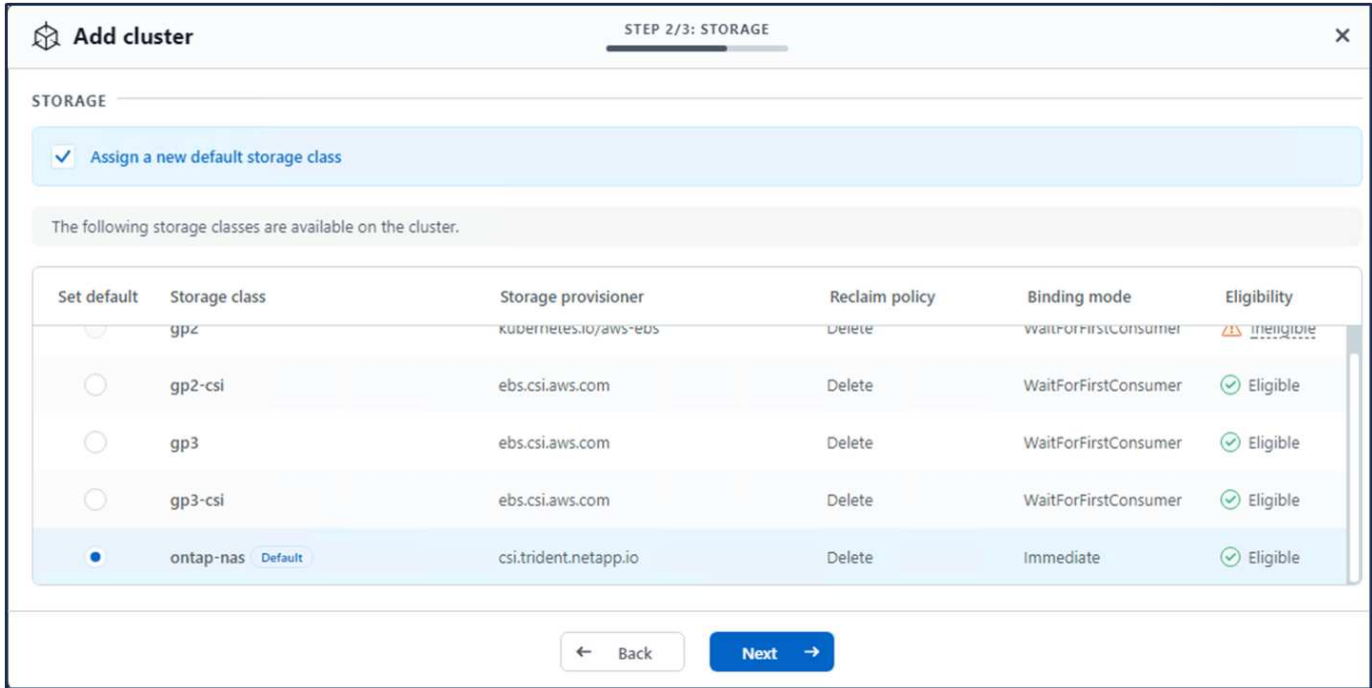
erp=# SELECT * FROM persons;
 id | firstame | lastname
-----|-----|-----
  1 | John    | Doe
(1 row)
```

## 7. Add the cluster into ACS

Log in to ACS. Select cluster and click on Add. Select other and upload or paste the kubeconfig file.



Click **Next** and select `ontap-nas` as the default storage class for ACS. Click **Next**, review the details and **Add** the cluster.



**8. Define the application in ACS**

Define the postgresql application in ACS. From the landing page, select **Applications**, **Define** and fill in the appropriate details. Click **Next** a couple of times, Review the details and click **Define**. The application gets

added to ACS.

STORAGE

✓ Assign a new default storage class

The following storage classes are available on the cluster.

Set default	Storage class	Storage provisioner	Reclaim policy	Binding mode	Eligibility
<input type="radio"/>	gp2	kubernetes.io/aws-ebs	Delete	WaitForFirstConsumer	Unavailable
<input type="radio"/>	gp2-csi	ebs.csi.aws.com	Delete	WaitForFirstConsumer	Eligible
<input type="radio"/>	gp3	ebs.csi.aws.com	Delete	WaitForFirstConsumer	Eligible
<input type="radio"/>	gp3-csi	ebs.csi.aws.com	Delete	WaitForFirstConsumer	Eligible
<input checked="" type="radio"/>	ontap-nas <small>Default</small>	csi.trident.netapp.io	Delete	Immediate	Eligible

← Back    Next →

## 9. Create a snapshot using ACS

There are many ways to create a snapshot in ACS. You can select the application and create a snapshot from the page that shows the details of the application. You can click on Create snapshot to create an on-demand snapshot or configure a protection policy.

Create an on-demand snapshot by simply clicking on **Create snapshot**, providing a name, reviewing the details, and clicking on **Snapshot**. The snapshot state changes to Healthy after the operation is completed.

Dashboard    Applications    Clusters    Cloud instances    Buckets    Account    Activity    Support

Data protection    Storage    Resources    Execution hooks    Activity    Tasks

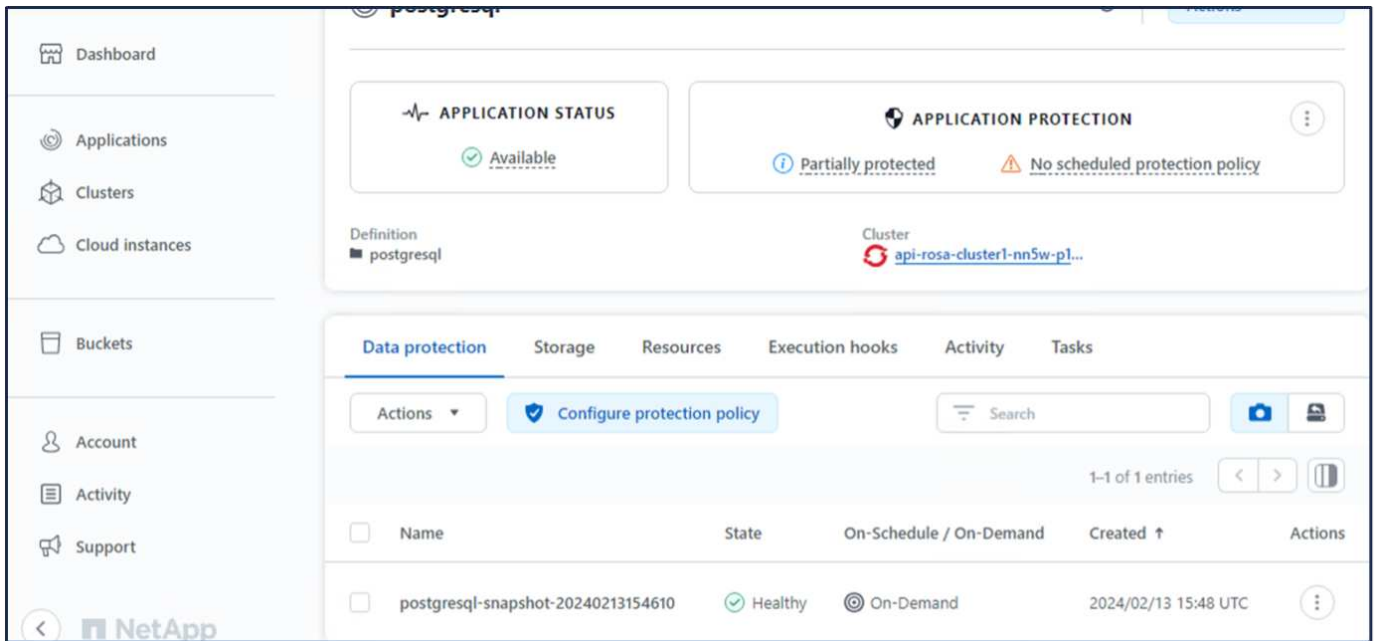
Actions    Configure protection policy    Search

0-0 of 0 entries

<input type="checkbox"/>	Name	State	On-Schedule / On-Demand	Created ↑	Actions
--------------------------	------	-------	-------------------------	-----------	---------

You don't have any snapshots  
After you have created a snapshot, it will be listed here

Create snapshot



## 10. Delete the database in the postgresql application

Log back into postgresql, list the available databases, delete the one you created previously and list again to ensure that the database has been deleted.

```

postgresql=# \l
          List of databases
  Name      | Owner   | Encoding | Locale Provider | Collate | Ctype  | ICU Locale | ICU Rules | Access privileges
-----+-----+-----+-----+-----+-----+-----+-----+-----
erp        | postgres | UTF8     | libc            | en_US.UTF-8 | en_US.UTF-8 |             |             | 
postgres  | postgres | UTF8     | libc            | en_US.UTF-8 | en_US.UTF-8 |             |             | 
template0  | postgres | UTF8     | libc            | en_US.UTF-8 | en_US.UTF-8 |             |             | =c/postgres
+
template1  | postgres | UTF8     | libc            | en_US.UTF-8 | en_US.UTF-8 |             |             | postgres=Ctcl/
+
(4 rows)

postgresql=# DROP DATABASE erp;
DROP DATABASE
postgresql=# \l
          List of databases
  Name      | Owner   | Encoding | Locale Provider | Collate | Ctype  | ICU Locale | ICU Rules | Access privileges
-----+-----+-----+-----+-----+-----+-----+-----+-----
postgres  | postgres | UTF8     | libc            | en_US.UTF-8 | en_US.UTF-8 |             |             | =c/postgres
+
template0  | postgres | UTF8     | libc            | en_US.UTF-8 | en_US.UTF-8 |             |             | postgres=Ctcl/
+
template1  | postgres | UTF8     | libc            | en_US.UTF-8 | en_US.UTF-8 |             |             | postgres=Ctcl/
+
(3 rows)

```

## 11. Restore from a snapshot using ACS

To restore the application from a snapshot, go to ACS UI landing page, select the application and select

Restore. You need to pick a snapshot or a backup from which to restore. (Typically, you would have multiple created based on a policy that you have configured). Make appropriate choices in the next couple of screens and then click on **Restore**. The application status moves from Restoring to Available after it has been restored from the snapshot.

Dashboard

Applications

Clusters

Cloud instances

Buckets

Account

Activity

Support

postgresql

APPLICATION STATUS: Available

APPLICATION PROTECTION: Partially protected, No scheduled protect

Definition: postgresql

Cluster: api-rosa-cluster1-nn5w-p1-op...

Data protection | Storage | Resources | Execution hooks | Activity | Tasks

Actions | Configure protection policy | Search

1-1 of 1 entries

<input type="checkbox"/>	Name	State	On-Schedule / On-Demand	Created ↑	Actions
<input checked="" type="checkbox"/>	postgresql-snapshot-20240213164912	Healthy	On-Demand	2024/02/13 16:50 UTC	

RESTORE TYPE

Restore the application to new namespaces on any available cluster or to original namespaces on the original cluster.

Restore to new namespaces

Restore to original namespaces

RESTORE SOURCE

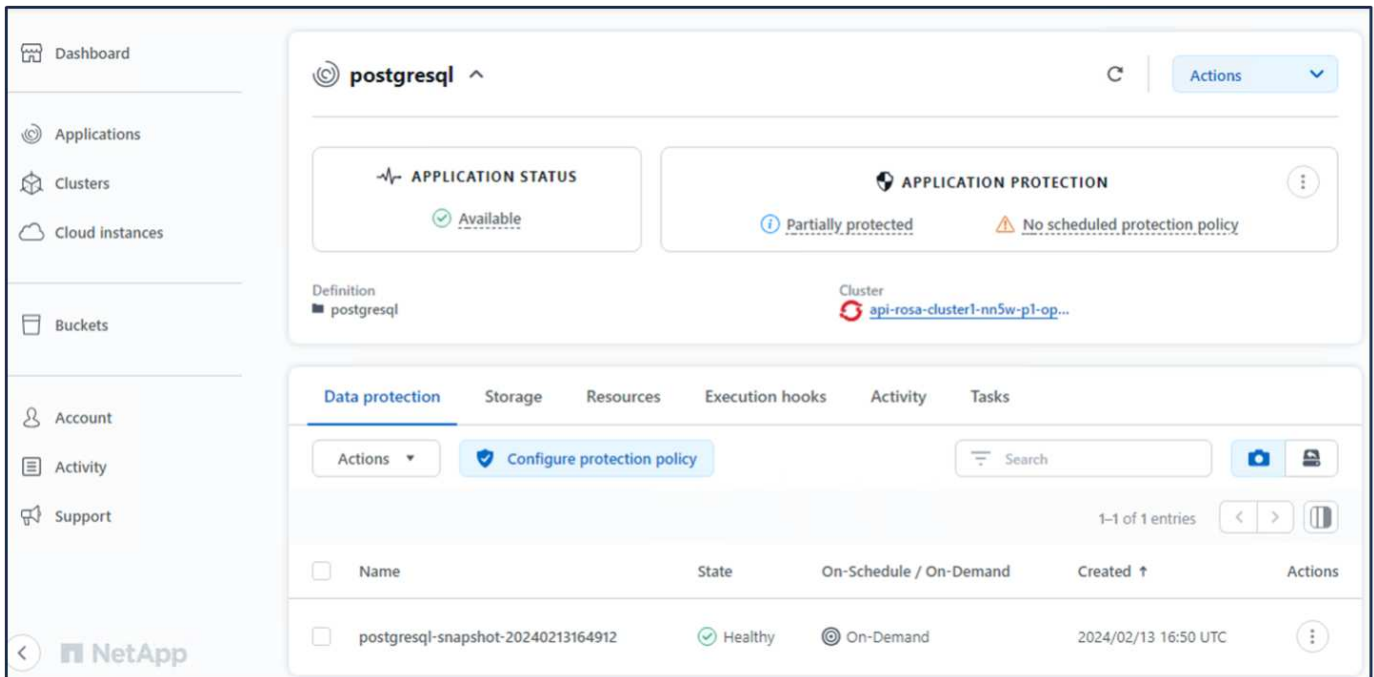
Select a snapshot or backup to restore the application to a previous state.

Time range | Filter | Snapshots | Backups

<input checked="" type="radio"/>	Application snapshot	Snapshot state	On-Schedule / On-Demand	Created ↑
<input checked="" type="radio"/>	postgresql-snapshot-20240213164912	Healthy	On-Demand	2024/02/13 16:50 UTC

Cancel | Next →





## 12. Verify your app has been restored from the snapshot

Login to the postgresql client and you should now see the table and the record in the table that you previously had. That's it. Just by clicking a button, your application has been restored to a previous state. That is how easy we make it for our customers with Astra Control.

```
[ec2-user@ip-10-49-11-132 ~]$ kubectl run postgresql-client --rm --tty -i --restart='Never' --namespace postgresql --image docker.io/bitnami/postgresql:16.2.0-debian-11-r1 --env="PGPASSWORD=$POSTGRES_PASSWORD" --command -- psql --host postgresql -U postgres -d postgres -p 5432
Warning: would violate PodSecurity "restricted:vl.24": allowPrivilegeEscalation != false (container "postgresql-client" must set securityContext.allowPrivilegeEscalation=false), unrestricted capabilities (container "postgresql-client" must set securityContext.capabilities.drop=["ALL"]), runAsNonRoot != true (pod or container "postgresql-client" must set securityContext.runAsNonRoot=true), seccompProfile (pod or container "postgresql-client" must set securityContext.seccompProfile.type to "RuntimeDefault" or "Localhost")
If you don't see a command prompt, try pressing enter.

postgresql=# \l
          List of databases
  Name | Owner  | Encoding | Locale Provider | Collate | Ctype  | ICU Locale | ICU Rules | Access privileges
-----+-----+-----+-----+-----+-----+-----+-----+-----
 erp   | postgres | UTF8     | libc             | en_US.UTF-8 | en_US.UTF-8 |              |              |
 postgres | postgres | UTF8     | libc             | en_US.UTF-8 | en_US.UTF-8 |              |              |
 template0 | postgres | UTF8     | libc             | en_US.UTF-8 | en_US.UTF-8 |              |              | =c/postgres
 template1 | postgres | UTF8     | libc             | en_US.UTF-8 | en_US.UTF-8 |              |              | =c/postgres
 postgres-C1c/postgres
(4 rows)

postgresql=# \c erp
You are now connected to database "erp" as user "postgres".
erp=# \dt
          List of relations
 Schema | Name  | Type  | Owner
-----+-----+-----+-----
 public | persons | table | postgres
(1 row)

erp=# SELECT * from PERSONS;
 id | firstame | lastname
----+-----+-----
  1 | John    | Doe
(1 row)
```

## Data migration

This page shows the data migration options for container workloads on Managed Red Hat OpenShift clusters using FSx for NetApp ONTAP for persistent storage.

## Data Migration

Red Hat OpenShift service on AWS as well as FSx for NetApp ONTAP (FSxN) are part of their service portfolio by AWS. FSxN is available on Single AZ or Multi-AZ options.

Multi-Az option provides data protection from availability zone failure.

FSxN can be integrated with Astra Trident to provide persistent storage for applications on ROSA clusters.

### Integration of FSxN with Trident using Helm chart

#### [ROSA Cluster Integration with Amazon FSx for ONTAP](#)

The migration of container applications involves:

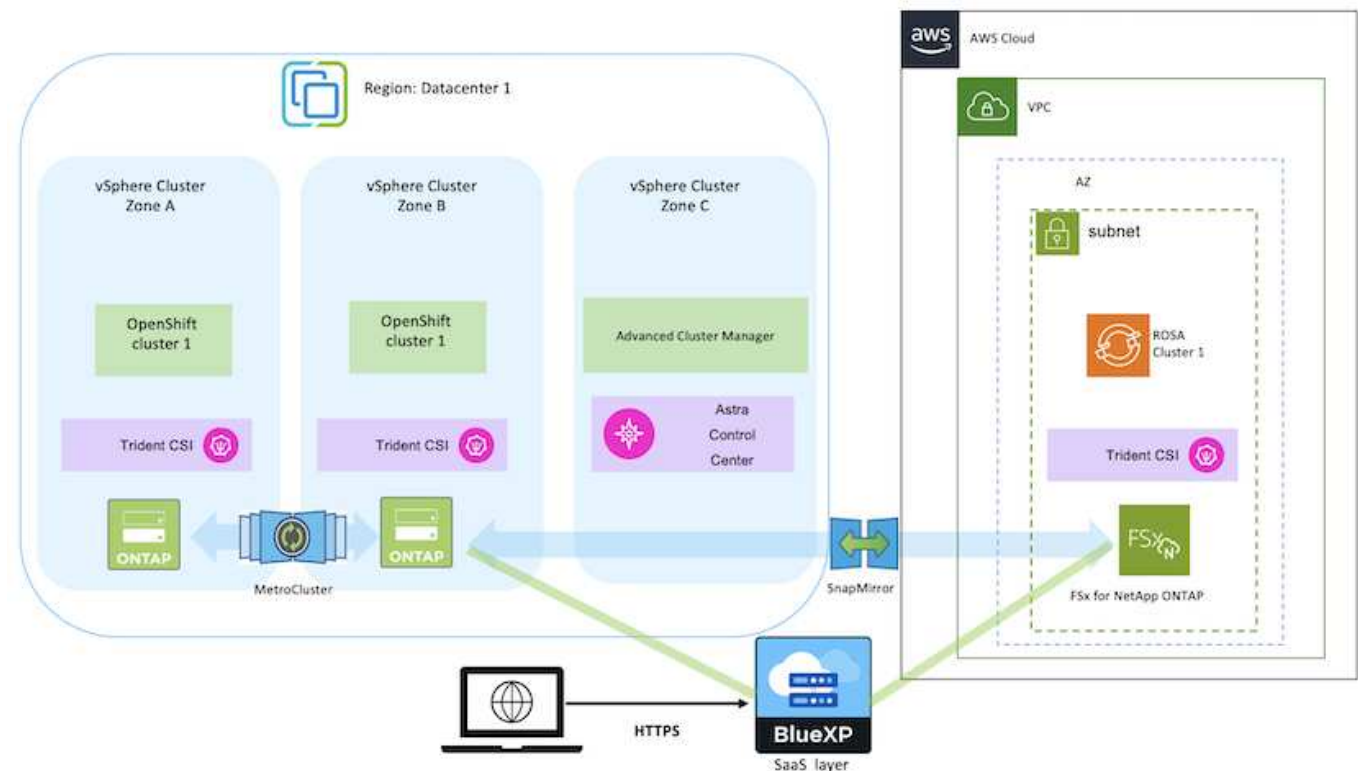
- Persistent volumes: this can be accomplished using BlueXP. Another option is to use Astra Control Center to handle container application migrations from on-premises to the cloud environment. Automation can be used for the same purpose.
- Application metadata: this can be accomplished using OpenShift GitOps (Argo CD).

### Failover and Fail-back of applications on ROSA cluster using FSxN for persistent storage

The following video is a demonstration of application failover and fail-back scenarios using BlueXP and Argo CD.

#### [Failover and Fail-back of applications on ROSA cluster](#)

### Data protection and migration solution for OpenShift Container workloads



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